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THE FAT-SOLUBLE VITAMIN CONTENT OF THE LIVER OIL OF THE BURBOT[1]

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The burbot, *Lota maculosa*, is known by a variety of names—ling, eelpout, lawyer, freshwater cod, and freshwater cusk—to mention some of the most common. It is the only freshwater member of the cod family, all its relatives living in the sea. Many authorities consider that the American and the European species, *Lota lota*, are closely related, if not identical. If the two are to be regarded as the same species, then the geographical range of the burbot is nearly co-extensive with the freshwaters of the northern hemisphere. Its habitat has been recorded by Small (*37*), Day (*13*), Goode (*20*), Forbes (*18*), Jordan *(26)*, Jordan and Everman *(27, 28)* and Jordan, Everman and Clark (*29*). Halkett (*21*) found that the burbot was "well-nigh cosmopolitan in northern North America, recorded from Labrador, and ranging from New Brunswick westward to British Columbia; and from the Arctic regions southward to the northern States." Dymond (*17*) found burbot in Lake Nipigon, and Mackenzie (*30*) in Silver Lake, Ontario.

The burbot is a very heavy cannibal feeder, destroying large quantities of marketable fish, chiefly ciscoes and perch. Judging from the catches in a survey made at intervals from September 1928, to September 1930, its most common associates are whitefish, herring and lake trout. It is a food competitor with the last, subsisting chiefly on ciscoes and alewives, although many stomachs contain the deep-water sculpin, and at certain seasons the burbot seems to have eaten *Mysis relicta* almost entirely. As an example of their appetite, an examination of one stomach showed thirty-nine sculpins, six alewives, one herring seven inches and one herring nine inches in length. The burbot is so abundant in deep water that it is a nuisance to the fishermen who find it in great numbers in gill nets, particularly those set for whitefish. There is little or no market for burbot as food and hence the fisherman must either remove it from the nets and throw it overboard or bring the catch to shore and bury them.

If a market is created for this fish as edible food—and plans for such a market are being considered—the liver oil would be a valuable by-product.

Body Weight and Liver Weight.—Some 356 burbot, 189 males and 167 females, obtained during this survey, were measured, weighed in the round and their livers removed and weighed. Their body weights varied from 7 pounds 7 ounces to 1 pound 4 ounces, with an average weight of

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3 pounds 3 ounces. The fish were taken in 6½-inch, 4-inch, and 3-inch mesh gill nets in depths of water ranging from 40 to 200 feet, being most common between 75 and 125 feet.

The liver weights varied from 13 ounces to 2 ounces with an average weight of 5.1 ounces. Thus the liver makes up about 10% of the body weight, being relatively much larger than the liver of the cod.

Extraction of Oil.—The method used for extraction of the liver oil was a laboratory modification of the direct steam method which is now almost universally used for the extraction of medicinal cod liver oil. The livers were removed in fresh condition from the burbot, the gall bladder removed, and the livers then washed in cold water. The livers were placed in a 3-litre beaker and steam was led in by a perforated tube extending to the bottom.

The mass of livers was subjected to steam for 45 minutes with intermittent stirring. After cooling, the mass was placed in a flannelette, canvas, or aeroplane-silk bag and allowed to drain. The oil was separated from the water by means of a separatory funnel. After draining, the "chum" remaining in the bags was pressed under increasing pressure, until no more oil could be expressed. All supplies of oil were then combined and filtered through Chardin paper to remove all liver particles.

Yield of Oil.—Twenty determinations of the percentage yield of oil were made during the survey at intervals of several months. These varied from 31.2 to 48.5% with an average of 38.4%. Similar determinations made with cod livers throughout the summer months of 1928, showed a variation from 14.0 to 37.4% with an average of 28.2%. During the course of this investigation Clow and Marlatt (*12*) using a modification of the indirect method of steam extraction reported a yield of oil varying from 36 to 56%. Apparently the livers of the burbot, as well as being relatively larger, contain more oil than those of the cod. The oil was of pale yellow colour and compared favourably in colour and taste with medicinal cod liver oil. Nelson, Tolle and Jamieson (*34*) reported that burbot liver oil has chemical and physical properties very similar to those of cod liver oil.

VITAMIN A ASSAY

1. Biological

A preliminary study by McCollum and Simmonds (*31*) indicated that 2% of cod liver oil and 3% of burbot liver oil were effective in the prompt cure of incipient xerophthalmia. In a private communication McCollum informed the writer that these statements rested upon experiments done in his laboratory about 1920, on burbot liver oil obtained from Sturgeon Bay, Wisconsin. Branion (*6*, *7*, *8*), reported that burbot liver oil was a potent source of vitamin A.

Since the conclusion of this investigation Nelson, Tolle and Jamieson (*34*) have found that burbot liver oil, prepared under commercial conditions was from 4 to 10 times as potent in vitamin A as good grades of medicinal cod liver oil.

The quantitative estimation of vitamin A, as described by Sherman and Munsell (*35*), which is essentially the method adopted by the United States Pharmacopeia, was used with the modifications suggested by the Accessory Food Factors (Vitamins) Committee (*1*)—primarily the in-

clusion of vitamin D in the diet. Young albino rats of 40–50 g. weight, 20–30 days old are placed on a vitamin A free-diet, until growth ceases. After seven days of stationary or declining weight, the source of vitamin A under test is incorporated in graded doses, into the diet. Not only is there a cessation of growth in the young when vitamin A is deficient but both young and old show a decline in health usually terminating in death. Mellanby and Green (*33*) have indicated that these characteristic symptoms are associated with an undermining of the body resistance to infection. Experimental animals used for this type of assay must have at the time growth ceases such a disturbance in metabolism that recovery, even when vitamin A is fed, must be extremely slow. Moreover, the present trend of vitamin therapeutics, lies in the direction of prevention rather than cure. Many inherent difficulties, primarily individual variations in response, are encountered in this assay. Such difficulties have been clearly summarized by Drummond (*14*, *15*). In the author's opinion, if biological assays are to be continued in use, a "preventive" type of assay should be substituted. A modification of the assay of Sherman and Munsell, using the same diet, but including graded doses of the oil under test in the A-free ration from the beginning of the experiment, and basing the potency on the minimal daily dose which will give normal growth and prevent the onset of infection over an eight week period, has given fair satisfaction. This minimal dose is usually less than the minimum using the curative assay. A comparison of the quantities of various vitamin preparations necessary to induce the same rate of growth, rather than a growth rate of 3 grams a week, appears to be more satisfactory. In both assays irradiated ergosterol (viosterol) was used as a source of the antirachitic vitamin.

The Sherman and Munsell assay requires young rats from mothers kept on a fairly strict ration. This ration is supposedly not deficient in vitamin A but contains sufficient to meet the requirements of the nursing mother without enabling her to pass on a store to the young, which are to be used as test animals. Difficulties were encountered with this stock ration even when 1% of calcium carbonate was substituted for part of the sodium chloride, as recommended by Smith (*38*). The litters were apparently born in good condition, but in numerous cases the mother refused to nurse them. At other times the mother did nurse her young but they did not thrive and died within a week. When the breeders were continued on this ration for a period of months, the number of litters, and the size of the litters was markedly reduced. The antirachitic requirements of the stock colony were assured by irradiated ergosterol.

The addition of 10 cc. of fresh milk daily to the nursing mother during pregnancy and the first two weeks of lactation overcame these difficulties. There was no appreciable increase in the time required for cessation of growth in young rats from mothers kept on this regime. This would seem to suggest that Sherman's diet is deficient in vitamin A. The obvious conclusion was a deficiency in the powdered wholemilk. Various brands of powdered milk gave no better results. In a private communication Sherman advised the feeding of fresh lean meat to the stock colony.

Further investigation showed that the addition of 2% to 5% of dried brewer's yeast improved the growth of young rats kept on Sherman's diet. The subsequent addition of the yeast in the breeder's diet alleviated some

of the difficulties. An improvement in the general well-being of the colony was also achieved by the feeding of green stuff, lettuce or cabbage, daily.

Furthermore, when young rats, whose mothers were kept on the original diet, were placed on the A-free diet, growth ceased within a week, instead of the usual three to five weeks. Such results would indicate that Sherman's ration is deficient in fat-soluble vitamins and in some fraction or fractions of the water-soluble B complex. Sherman and Smith (*36*) point out that their diet was not recommended as an optimal food either for growth or for reproduction. During the latter experiments the stock diet of Steenbock, as modified by Bills (*4*) was used with excellent results.

Some investigators claim that the development of xerophthalmia or keratomalacia in young rats, kept on a vitamin A deficient diet, precedes the cessation of growth. In fact, Steenbock and Coward use the cure of this incipient xerophthalmia as their sole criterion for vitamin potency, paying little or no attention to growth. Our results, in general, substantiate the findings of Brocklesby (*10*) that cessation of growth precedes the onset of xerophthalmia.

After the preliminary period for the exhaustion of the vitamin store, the oil was fed in various dilutions for 35 days. The use of the 5-week test period was decided upon in view of the progressive decrease in the rate of growth encountered in rats after 3 months of age, as pointed out by Hume and Smith (*25*) and Drummond and Morton (*14*). Even using this shorter test, in some instances the rate of growth of the rats under test was much less during the last weeks. This failure of growth could not be made good by increasing the amount of the vitamin supplement.

In the earlier experiments paraffin oil was used for the dilution of the burbot oil. In later experiments sesame or corn oil was used. Several investigators have questioned the ability of the test animals to absorb mineral oils, and any vitamin preparation dissolved in them might be only partially absorbed, the remainder being swept out of the intestinal tract. The sesame or corn oil was always assayed to ascertain the absence of vitamin potency in these oils. Our results showed that .002 g. of the liver oil using paraffin oil for dilution was the minimum daily amount necessary to promote the required growth, whereas diluted with a vegetable oil, .0016 g. was the minimum dosage; being a difference in potency between 500 and 625 units. The use of the word "units," however, suggests a degree of accuracy which is not justified. Biological assays should be considered as approximations only as Ahmad and Drummond (*2*) pointed out.

Some thirty biological assays for vitamin A potency were carried out. Oils extracted from livers obtained from burbot caught at different months of the year were assayed to show any seasonal variations in potency. These assays indicated some variations, the potency increasing from the time of spawning to the late winter or early spring, and reaching a maximum in August or September. The results must be considered, however, in view of the inaccuracy of biological assays, as merely indicating a general trend. Future investigations may permit more definite conclusions. All assays showed a vitamin potency of 500 units or better.

The results are summarized in Table 1 and are the averages of all experiments.

TABLE 1.—VITAMIN A POTENCY OF BURBOT LIVER OIL

Source of vitamin (daily)	Increase in weight (35 day test period)	Incipient xerophthalmia
.020 g. oil	42 g.	Cured
.010 g. oil	40 g.	Cured
.007 g. oil	43 g.	Cured
.004 g. oil	25 g.	Cured
.003 g. oil	24 g.	Cured
.002 g. oil	19 g.	Cured in 90% of cases, improved in all cases

Not less than three animals were used in each assay for each dose of oil, the oil being administered orally to individuals. Negative controls, fed the deficient ration, were maintained with each experiment. In all assays these controls lost weight and died during the test period. Litter mates and males and females were divided among the groups as far as possible.

Typical growth curves are given in Figures 1, 2, and 3.

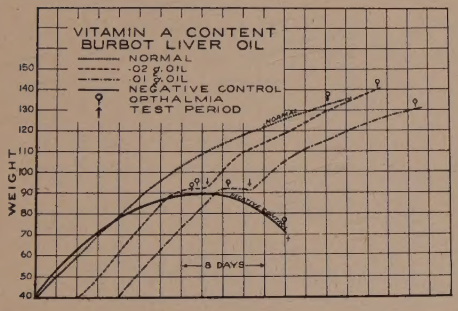

FIGURE 1. Growth curves of rats, showing the growth promoting properties of a daily dosage of .02 g. and .01 g. of burbot liver oil, added to a vitamin A deficient diet, after cessation of growth. For comparison, the growth curve of a rat on a normal diet and one on the vitamin deficient diet with no supplement, are included.

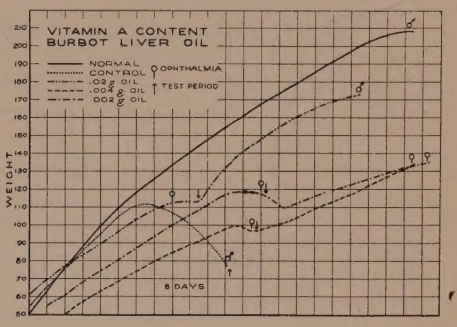

FIGURE 2. Growth curves of rats showing the growth-promoting properties of a daily supplement of .02 g., .004 g. and .002 g. of burbot liver oil to a vitamin A deficient diet.

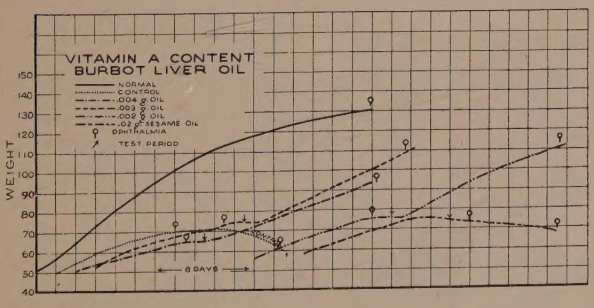

FIGURE 3. Showing the growth-promoting properties of a daily supplement of .004 g., .003 g. and .002 g. of burbot liver oil to a vitamin A deficient diet. The failure of a daily dose of .02 g. of sesame oil to promote growth is also shown.

The results of the biological assays show that burbot liver oil is a potent source of vitamin A. Based on this assay, its potency would be 500 units per gram. The U.S.P. requirement for medicinal cod liver oil is 50 units per gram, although most medicinal oils contain from 250 to 500 units.

The daily administration of .002 g. of the oil in every case gave at

least the weekly growth of 3 grams as required by the method. The incipient ophthalmia was not completely cured in all cases with this minimum dosage, but there was a marked improvement. Since, as had been pointed out, this type of biological assay does not seem to give the accuracy necessary for a minute determination of unit potency, without the use of a prohibitive number of animals, it was felt that further assaying of greater dilutions was not warranted. The oil is at least as potent in vitamin A as most, if not all, medicinal cod liver oils.

It was observed in the course of these assays and of other assays carried out with various samples of cod liver oil during the period, that increasing dilution of the oils sometimes leads to a level of dosage which will promote growth of 10 to 20 grams, or even better, in 35 days, but which seems to exert little or no curative effect on the induced ophthalmia. A possible explanation of these observations would be a dual nature of vitamin A. Such a suggestion has been advanced by other workers in this field. These results indicate a line of attack which might prove fruitful in the establishment of this duality—A_1 being a growth factor and A_2 the anti-infective factor.

It is of practical importance that the vitamin A content of burbot liver oil, kept at room temperature in a bottle which was opened for a few minutes three times a day, dropped from a potency of 500 units per gram to less than 50 units in six months.

2. Colorimetric

For the colorimetric assay of vitamin A the antimony trichloride method was used, as adopted by the Accessory Food Factors (Vitamins) Committee (*1*). This is comparable to Drummond's (*15*) technique B. Burbot liver oil, in 10% solution, gave blue colours ranging from 12.6 to 13.6 Lovibond units, with an average of 13 units, measured on a Rosenheim-Schuster tintometer. A medicinal cod liver oil measured at the same time gave a blue colour of 8.6 units. Various cod liver oils assayed by the same methods have varied from 6 to 12 blue units. Drummond suggested that cod liver oil for human consumption should show greater than 7 blue units measured by Technique B.

The colorimetric assay would rank burbot liver oil as an excellent source of vitamin A.

VITAMIN D ASSAY

The preliminary study of McCollum and Simmonds (*31*) showed that burbot liver oil contained the antirachitic vitamin. Clow and Marlatt (*12*), also using the liver oil of burbot caught in Sturgeon Bay, reported that burbot liver oil could be classed with cod liver oil as an excellent source of the antirachitic vitamin. As a matter of fact it was about eight times as potent as the particular medicinal oil against which it was tested. Branion (*7*, *8*) reported that burbot liver oil was a potent source of vitamin D. Since these assays were finished Steenbock, Kletzien and Halpin (*40*) and Halvarson (*22*) have demonstrated that burbot liver oil will serve as an antirachitic agent for young chicks. Nelson, Tolle and Jamieson (*34*) found this oil to be 3 to 4 times as potent in vitamin D as medicinal cod liver oil.

EXPERIMENTAL

Young albino rats, 30 days old, from a stock colony kept on Bills' diet, were placed on McCollum's (*31*) rachitogenic diet No. 3143 or on Steenbock's (*39*) rickets-producing diet No. 2965. Preventive rather than curative assays were carried out since it was felt that the present therapeutic use of antirachitic preparations was in the direction of the prevention rather than in the cure of rickets. The burbot liver oil was fed daily by mouth in varying dilutions with sesame oil, and its vitamin potency was judged by Roëntgen-ray examination of the knee-joint, made at the end of a 30 day test period. Negative controls were maintained on the diet without oil. Inorganic blood phosphate determinations were carried out by Brigg's (*9*) modification of the method of Bell and Doisy, on the pooled blood from each group of animals.

Some difficulties have arisen in the production of rickets by the use of either rachitogenic diet. Mild anorexia and cessation of growth, followed by the "spontaneous cure" of the induced rickets has not been uncommon. The addition of a small amount of green feed daily (lettuce or spinach) has usually improved the rats' appetite.

Harris and Bunker (*23*) reported on the irregularity of the development of rickets which they believed to be due to antirachitic properties of the corn. Goldblatt (*19*) claimed that this irregularity on the rachitogenic diets either 2965 or 3143 was due either to the settling out of the calcium carbonate or to inanition. In this laboratory the addition of 5% dried brewer's yeast to diet 2965 has entirely alleviated the difficulties. This indicates that inanition and poor growth are the cause of the irregularity.

Some typical results of the inorganic blood phosphorus determinations are given in Table 2.

TABLE 2.—INORGANIC BLOOD PHOSPHATE

Diet	P in mg per 100 c.c. plasma		
	I	II	III
Normal	9.0	6.5	6.3
Rachitogenic No. 3143	1.9	—	—
Rachitogenic No. 2965	—	1.8	2.8
Rachitogenic + .020 g. burbot liver oil	5.9	6.6	—
Rachitogenic + .010 g. burbot liver oil	4.0	3.4	—
Rachitogenic + .004 g. burbot liver oil	2.6	4.3	3.1
Rachitogenic + .003 g. burbot liver oil		4.1	3.5
Rachitogenic + .002 g. burbot liver oil		3.2	3.2
Rachitogenic + .0016 g. burbot liver oil		4.4	4.3
Rachitogenic + .0013 g. burbot liver oil		2.7	
Rachitogenic + .020 g. 1X Viosterol*		4.0	
Rachitogenic + .020 g. Sesame Oil		1.1	

*250 D or 100 × viosterol was diluted to 100 volumes, *i.e.* to the vitamin D potency of a good cod liver oil.

According to Cavins (*11*) the normal inorganic phosphorus level of rat blood serum is 7 to 8 mg. per 100 cc. and in rachitic animals on a low phosphorus diet (McCollum 3143) as 2 to 3 mg. Dutcher, Creighton and Rothrock (*16*) found the concentrations to be 8 mg. and 1.6 mg. per 100

cc. respectively. In the course of these experiments the normal inorganic plasma levels varied from 5.5 to 9.0 with an average of 6.9 mg. per 100 cc. and the rachitic levels from 1.3 to 4.4 with an average of 2.7 mg. per 100 cc. However, as Hess, Weinstock, Rivkin and Gross (*24*) have reported a lack of relationship between the development and cure of rickets and the inorganic phosphorus concentration of the blood, it is probable that blood phosphorus levels give little more than a qualitative indication of the course of rickets.

Figure 4 shows some Roëntgen-ray photographs of the knee-joint of typical individuals, together with the inorganic blood phosphorus levels of the pooled group which they represent, obtained during the course of experimental work on rickets in rats.

It is seen that there is no direct relationship between rickets and the inorganic phosphorus, other than a general indication of the condition. The Roëntgen-ray photograph of Rat 52 reveals very severe rickets and the plasma inorganic phosphorus was 3.8 mg. per 100 cc., whereas the Roëntgen-ray examination of Rat E1 shows no sign of rickets and the plasma inorganic phosphorus was 2.6 mg. per 100 cc. The photograph of Rat 12 shows little, if any, sign of rickets with a plasma inorganic phosphorus of 1.5 mg. per 100 cc. These results confirm the findings of previous investigators. The values given in Table 2 also show no uniformity of blood phosphorus levels with the vitamin intake.

Roëntgen-ray examination of the knee-joint definitely establishes the presence or absence of rickets and further will, in most cases, show the deposition of any new-formed bone. It is not suggested that this examination should take the place of the various modifications of the original line test of McCollum, Simmonds, Shipley and Park (*32*), but if suitable X-ray facilities are available it seems to be as satisfactory, especially in a preventive type of assay.

Four series of such photographs with burbot liver oil in graded doses are shown in Figures 5, 6, 7 and 8. The fifth series shows results obtained with two medicinal cod liver oils.

Series 1, using a liver oil obtained from burbot caught early in June, shows that the lowest dosage of oil, .004 g. daily, gave much better bone formation than the control, although it did not completely protect from rickets.

In series 2, using a July oil, similar results are shown, .004 g. daily being the lowest level which gave complete protection. However, still lower doses down to a .0016 g. daily intake gave improved bone formation over the control, and all show evidence of bone deposition. The lowest level .0013 g. daily shows little if any improvement over the rachitic animals. The levels of oil from .003 g. to .0016 g. daily seem to have afforded protection equal to that given by .02 g. of a 1 × preparation of viosterol.

An August oil, used in series 3, gives evidence of protection at a daily intake of .004 g. and shows bone deposition at an intake of .002 g. but a daily dose of .0016 g. shows no evidence of therapeutic value.

As will be seen in series 4, the use of .0016 g. of September burbot liver oil has afforded complete protection against rickets. These results

FIGURE 4. Roëntgen-ray photographs of knee-joint of rats fed rachitogenic diet 2965. E 1—Plasma inorganic phosphorus 2.6 mg. per 100 cc. (No rickets). E 12—Plasma inorganic phosphorus 1.5 mg. per 100 cc. (Very slight rickets). 52—Plasma inorganic phosphorus 3.8 mg. per 100 cc. (Severe rickets). M 3—Plasma inorganic phosphorus 2.8 mg. per 100 cc. (Fairly severe rickets).

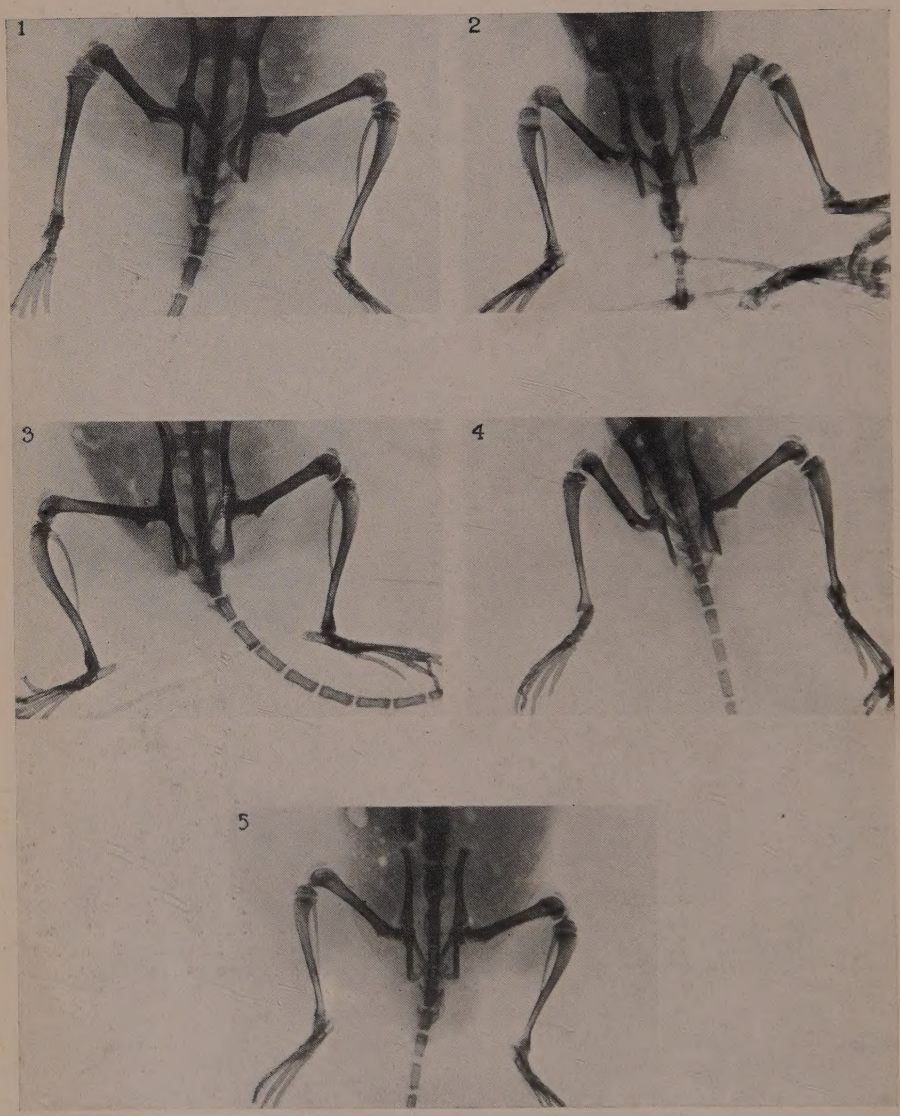

FIGURE 5. Antirachitic potency of June burbot liver oil. Series 1—Roëntgen-ray photographs of knee joints. 1. Normal. 2. Rachitic. 3. Rachitic plus .02 g. of oil. 4. Rachitic plus .01 g. of oil. 5. Rachitic plus .004 g. of oil daily.

FIGURE 6. Antirachitic potency of July burbot liver oil. Series 2—Roëntgen-ray photograph of knee joints. 1. Normal. 2. Rachitic. 3. Rachitic plus .02 g. of oil. 4. Rachitic plus .01 g. of oil. 5. Rachitic plus .004 g. of oil. 6. Rachitic plus .003 g. of oil. 7. Rachitic plus .002 g. of oil. 8. Rachitic plus .0016 g. of oil. 9. Rachitic plus .0013 g. of burbot liver oil, daily. 10. Rachitic plus .02 g. of 1 X viosterol daily.

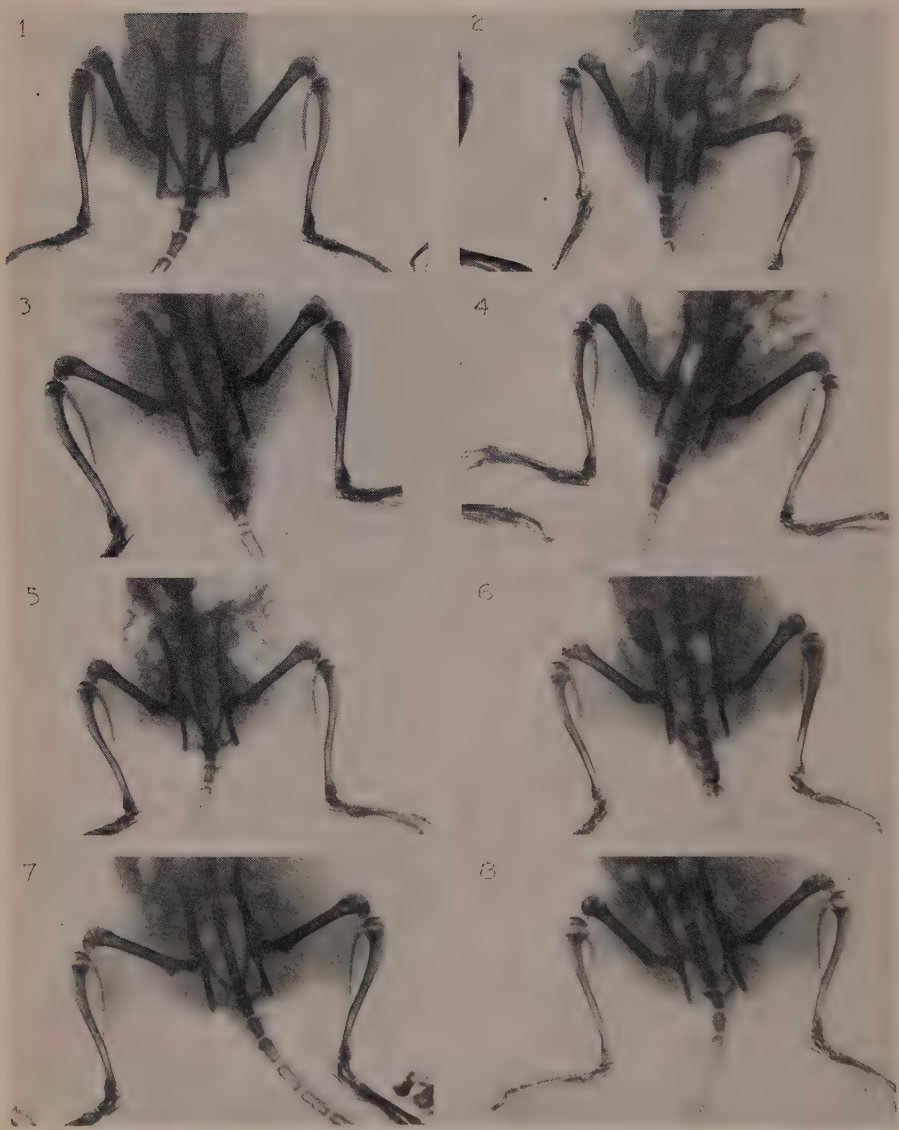

FIGURE 7. Antirachitic potency of August burbot liver oil. Series 3—Roëntgen-ray photographs of knee joints. 1. Normal. 2. Rachitic. 3. Rachitic plus .02 g. of oil. 4. Rachitic plus .01 g. of oil. 5. Rachitic plus .004 g. of oil. 6. Rachitic plus .003 g. of oil. 7. Rachitic plus .002 g. of oil. 8. Rachitic plus .0016 g. of burbot liver oil daily.

FIGURE 8. Antirachitic potency of September burbot liver oil. Series 4—Roëntgen-ray photographs of the knee joints. 1. Normal. 2. Rachitic. 3. Rachitic plus .004 g. of oil. 4. Rachitic plus .003 g. of oil. 5. Rachitic plus .002 g. of oil. 6. Rachitic plus .0016 g. of Burbot liver oil daily.

FIGURE 9. Antirachitic potency of medicinal cod liver oils. Series 5—Roëntgen-ray photographs of the knee joints. 1. Normal. 2. Rachitic. 3. Rachitic plus .02 g. of oil. 4. Rachitic plus .004 g. of oil. 5. Rachitic plus .002 g. of Medicinal Cod Liver Oil No. 1 daily. 6. Rachitic plus .02 g. of oil. 7. Rachitic plus .004 g. of oil. 8. Rachitic plus .002 g. of Medicinal Cod Liver Oil No. 2 daily.

suggest that the vitamin D potency of burbot liver oil, like its vitamin A content increases to a maximum in the late summer. The old theory that the ultra-violet light in summer sunshine enabled the minute plankton to synthesize vitamin D, which was passed on from smaller to larger organisms until it reached its final resting place in the liver of the fish, would explain this phenomenon. Tisdall and Brown (*41*) showed that there was a marked increase in the antirachitic effect of sunlight in the spring and summer, that received from April to August in Toronto being eight times as potent as that in the winter. However, Bills (*3*) has advanced strong evidence that fish synthesize the vitamin, even when kept in the dark.

An examination of the photographs in series 5 indicates that .004 g. of these medicinal cod liver oils gave fairly complete protection but that .002 g. of the first oil gave no protection, and of the second oil gave very little protection.

These results show that burbot liver oil has a high content of the antirachitic vitamin, being at least as potent as medicinal cod liver oil, and being more potent than the two medicinal oils against which it was tested.

These assays of the fat-soluble vitamin content of burbot liver oil show that it could be substituted for cod liver oil. With the increasing need for a good source of liver oil for incorporation into rations for domestic animals, in particular poultry, this oil should meet a popular demand. Medicinal cod liver oil is sold at an almost prohibitive price to ordinary stockmen. Cheaper grades of "cod liver oil" have appeared on the markets, but, with a few exceptions, no vitamin assay is assured.

Some of these cheaper oils, apparently obtained by the sun-rendered process, are definitely deficient at least in vitamin A. Apart from the possibility of marketing burbot liver oil for human consumption, the use of the oil in stock rations would prove a source of profit to Ontario fishermen; and would also rid the lakes of a fish which is, up to the present time, of no value and whose predatory tendencies have cost the industry many thousands of dollars.

SUMMARY

1. Burbot livers are of relatively large size and give a high yield of an oil which compared favourably in colour and taste with cod liver oil.

2. The vitamin A content of the oil is 500 units per gram or better, judged by biological assay. Antimony trichloride colorimetric assay gives a blue colour of 13 units as compared with 8.6 blue units developed by a medicinal cod liver oil.

3. The liver oil of the burbot is a potent source of vitamin D. It has a higher antirachitic potency than two medicinal cod liver oils against which it was assayed.

4. Evidence is presented to show a deficiency in the Sherman stock diet for rat colonies used in vitamin assays.

5. Inorganic blood phosphorus determinations are of little value, if used alone, in the assaying of vitamin D.

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Résumé

La proportion de vitamine soluble dans la graisse dans l'huile du foie de la lotte. H. D. Branion, Université de Toronto, Toronto, Ont.

Les foies de lotte (ou loche) sont relativement gros et rendent beaucoup d'huile qui soutient avantageusement la comparaison avec l'huile de foie de morue au point de vue de la couleur et du goût. La proportion de vitamine A trouvée dans cette huile est de 500 unités ou plus par gramme, jugée par l'essai biologique. L'essai colorimétrique au trichlorure d'antimoine donne une couleur bleue de 13 unités tandis qu'une huile de foie de morue médicinale développe 8.6 unités bleues. L'huile de foie de la lotte est très riche en vitamine D. Elle a un pouvoir anti-rachitique plus élevé que les deux huiles de foie de morue médicinales, contre lesquelles elle a été essayée. L'auteur présente des preuves établissant l'insuffisance du régime alimentaire Sherman employé pour les colonies de rats, utilisées dans les essais de vitamine. Les déterminations du phosphore inorganique du sang, employées seules, n'ont que peu de valeur dans la détermination de la vitamine D.

AN ACCOUNT OF THE WESTERN HEMLOCK LOOPER, *ELLOPIA SOMNIARIA* HULST, ON CONIFERS IN BRITISH COLUMBIA

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INTRODUCTION

The purpose of this paper is to present a biological study of the western hemlock looper and to point out some of the ecological factors, such as parasites, predators, and weather conditions which influence the progress of outbreaks in British Columbia. An account of three airplane dusting projects is also given, with intent to point out the difficulties which may be encountered in undertaking such control operations.

RECENT OUTBREAKS IN BRITISH COLUMBIA

Heavy defoliation by the western hemlock looper occurred on two areas in British Columbia in 1928, one at Indian River, North Arm of Burrard Inlet, and the other on Gold Creek, west shore of Alouette Lake; several minor outbreaks were also examined.

Indian River Area.—On this area, the peak year of the infestation wa in 1928. The area extended from the mouth of the river up the canyon for a distance of six miles, varying in width from one-fourth to one-half mile. There was considerable spread of the infestation in 1929.

Seymour and Capilano Areas.—Areas of severe defoliation developed in the Seymour and Capilano Valleys in 1929. The Seymour Creek infestation reached the largest proportions of any that year. It extended along Seymour Creek from a point one-fourth mile below the storage reservoir, up the canyon for a distance of twelve miles. It had an average width of one-fourth mile. The adults were extremely abundant in the fall of 1929 for several miles down the canyon below the severe infestation, and eggs were deposited there in tremendous numbers.

Mill Creek Area.—This infestation, discovered in 1929, extended from the mouth of Mill Creek, northwest shore of Howe Sound, up the canyon for at least two miles. The width did not average more than one-fourth of a mile. The area has been logged and the remaining timber is of poor quality.

Coquitlam Lake Area.—In 1929 this area had reached 640 acres in extent, situated on the west side of Coquitlam Lake, near the southern end. In 1930 this infestation gave decided evidence of rapid decline.

Alouette Lake Area.—Two areas of looper defoliation were discovered near Alouette Lake in 1928. The one on the west side, near the lower end, comprised 320 acres, and the other, three miles up Gold Creek, was 800 acres in extent. These infestations appeared to have subsided in 1930.

Chehalis River Area.—Two reported areas were examined on the Chehalis River in 1929. One of these, approximately 400 acres, was at the mouth of the river where considerable defoliation occurred. The other area was situated five miles up the river. There was noticeable defoliation there in 1929, and great numbers of adults were noted that fall. The feeding was not heavy in 1930, possibly indicating a subsidence.

Popkum Area.—A small infestation was located at Popkum in November, 1929. This is near the Fraser River, about ten miles east of Chilliwack. It comprised twenty-five acres, but an inspection in September, 1930, indicated a definite subsidence.

Stanley Park.—Although there was no complete defoliation in Stanley Park in 1929, some of the trees lost from 30 to 40% of their needles and the moths were numerous in spots, indicating a rising infestation. Control measures on this area are dealt with later.

BIONOMICS

After considering all of the infested areas, it was decided to carry on an intensive study of the Indian River infestation.

The coniferous stand of this area consists of hemlock, *Tsuga heterophylla* Sarg., 60%; cedar, *Thuja plicata* Don., 20%; Douglas fir, *Pseudotsuga taxifolia* Britt., 12%; sitka spruce, *Picea sitchensis* Traut. and Mayer, 5%; and balsam, *Abies grandis* Lind., 3%. In some of the canyons there were a few scattered white pines, *Pinus monticola* Dougl., particularly on the northern portion of the area. The deciduous trees occurring on the area are alder, *Alnus sitchensis* Sarg.; willow, several species; maple, *Acer macrophyllum* Pursh.; vine maple, *Acer circinnatum* Pursh.; red elderberry, *Sambucus racemosa* L.; and wild crab-apple, *Pyrus rivularis* Dougl. The shrubbery consists of salal, *Gaultheria shallon* Pursh.; blueberry, *Vaccinium* sp.; huckleberry, *Vaccinium ovatum* Pursh.; salmonberry, *Rubus spectabilis* Pursh.; spirea, species undetermined, and thimbleberry, *Rubacer parviflorum* Rydb.

Oviposition

The egg of the western hemlock looper is .75 mm. long by .50 mm. in diameter, ovoid in shape, minutely, hexagonally reticulate, slightly compressed and with a saucer shaped depression at one end. In the centre of this depression there is a small tubercle. The eggs are bluish green when first deposited but under natural conditions soon turn to a pale yellow-white colour and remain thus throughout the winter. In the spring, just prior to hatching, they become dark gray with a graphite sheen. After emergence of the larvae the egg cases are semi-transparent with pale iridescent colours.

Six attempts to induce females to oviposit in confinement ended in failure.

Place of Oviposition.—Eggs were found on the undersides of hemlock needles, and on stems of branchlets, both on reproduction and on mature trees, from the lowest branches to the tops, generally placed near the base of the needle or at the middle, rarely near the tip. They were generally deposited in groups of from two to ten, rarely singly. In only one case were eggs found on the upper needle surface but here the situation was protected by the eaves of a house. In one or two instances eggs were found on the under surface of maple leaves *(Acer macrophyllum)*. These were the dried leaves of the previous season which were on the ground and probably had fallen subsequent to oviposition.

Eggs were found in the greatest numbers in moss, on limbs and trunks of practically all trees on the area. In this case the eggs were nearly always

deposited singly, glued to a single moss strand. Egg counts were made as follows:—

In one linear foot of moss from a hemlock limb three-fourths inches in diameter—78 eggs.

In one linear foot of moss from a hemlock limb one-fourth inch in diameter—120 eggs.

In one linear foot of moss from a vine maple trunk one and one-eighth inches in diameter—175 eggs.

Eggs were also found on the forest floor. Eighty-five eggs were found in one square foot of moss. These were attached singly to the moss strands. However, there were many places on the forest floor where no eggs could be found. Oviposition in such situations probably occurs only when the moths appear in extremely large numbers at the very peak of an infestation. A few eggs were found deposited in lint beneath the eaves of a house.

Hatching of eggs had already commenced when the area was first examined, on May 22nd, and many young larvae could be seen clinging to the hemlock needles and leaves of deciduous trees and shrubs. As many as twenty-four were counted on the under surface of one elderberry leaf. Hatching extended over a considerable period, commencing before May 22nd and extending to June 11th. A good opportunity for studying the winter mortality was not afforded at that time, but in the spring of 1930, 705 eggs were collected from the Seymour Canyon infestation. These were placed in the laboratory at a temperature of approximately 28° C. Hatching took place as shown in Table 1.

Table 1.—Hatching and parasitism of eggs. Number of eggs used 705

Date	Larvae emerged	Egg parasites*
May 5	72	
May 6	108	
May 7	114	1
May 8	38	5
May 9	12	16
May 10	4	20
May 12	1	22
May 15	0	22
May 16	0	2
May 19	0	1
May 21	0	3
May 22	0	7
May 23		1
May 26		9
May 27		2
May 28		4
May 30		1
Totals	349	116

**Telenomus* sp. near *danmani* Ratz.

After sufficient time had elapsed subsequent to the last parasite emergence, the remaining eggs were opened and examined. Sixty-five more parasites were found dead which, for some reason, had failed to emerge, although apparently fully developed. The totals then became:—

Larvae hatched—349	49.5%
Egg Parasites—181	25.7%
Unaccounted for—175	24.8%

The 24.8% probably represents the winter mortality of this particular area for this particular year.

Larvae

A hemlock looper larva just hatched, is 3 mm. long and .5 mm. in diameter, annulated with alternate dark brown and light gray bands.

The larvae are remarkably uniform in colour, but after the first moult commence to vary considerably. In later stages the larvae are pale green, yellow, brown, or dark gray with irregular, narrow and wavy black lines extending longitudinally. The full grown larva is 25 mm. to 27 mm. long with a head capsule 2.5 mm. in breadth. The body diameter varies from 2 mm. to 3 mm.

The head capsule measurements fall naturally into five classes corresponding to the respective instars. The average for each of these classes is as follows:—

First instar	.42 mm.
Second instar	.68 mm.
Third instar	1.06 mm.
Fourth instar	1.55 mm.
Fifth instar	2.21 mm.

According to Dyar's rule the above figures should follow approximately a regular geometrical progression. The ratio of increase is found to be .70; then by calculation:—

Breadth in fifth instar	2.21 mm.
Calculated breadth in fourth instar (.70 × 2.21)	1.547 mm.
Calculated breadth in third instar (.70 × 1.547)	1.083 mm.
Calculated breadth in second instar (.70 × 1.083)	.758 mm.
Calculated breadth in first instar (.70 × .758)	.530 mm.

Breadths found— .42; .68; 1.06; 1.55; 2.21
Breadths calculated—.53; .758; 1.083; 1.547.

These two series correspond closely enough to indicate clearly that all of the instars are represented and none have been missed. These measurements show that for the majority of larvae moulting occurred as follows:—

First moult between June 12th and June 30th (majority)
Second moult between June 24th and July 10th (majority).
Third moult between July 7th and July 24 (majority).
Fourth moult between July 19th and July 31st (majority).

The ability to ascertain which instar the majority of larvae represents at a given time is important in fixing the amount of dust to use per acre in airplane dusting.

Longevity without Food.—On June 5th, twelve newly hatched larvae were placed in a glass container with a closely woven cloth bound over the top. No food was provided. The vial was placed outside as near as possible to the place where the eggs were deposited. The first death occurred on June 12th. By June 13th, three larvae were dead and four more by June 14th. All larvae were dead by June 18th. From this it is apparent that newly hatched larvae can live from seven to fourteen days without food. This indicates that it is possible for them to move some distance to reach suitable food when the eggs are deposited in unfavourable situations.

Larval Habits.—Observations on the severity of feeding both in 1928 and 1929 indicated the following preference of food plants in descending degree:—

Conifers: hemlock, balsam, Douglas fir, spruce, cedar, white pine. (No evidence of feeding was found on yew.)

Deciduous trees: willow, crab-apple, vine maple, large leaf maple, alder, red elderberry.

Shrubs: huckleberry, salmon-berry, salal, spirea, thimbleberry.

On the most severe portion of the infestation, practically all plants were stripped of foliage. Even devil's club (*Echinopanax horridum* Dec. and Planch) was fed upon to a small extent.

Experiments were carried out to determine whether larvae could be reared entirely on other foliage than hemlock. From ten to twenty young larvae were caged with each of the following plants:—vine maple, huckleberry, willow, crab-apple, spirea, cedar, and spruce. Larvae were successfully reared through to adults on spruce alone, on huckleberry alone, and on combinations of huckleberry and crab-apple, and huckleberry and willow.

The larvae in the cage containing cedar fed comparatively little and failed to develop. Larvae apparently would not eat spirea. The attempt at rearing on vine maple alone was unsuccessful, although vine maples are often stripped clean during the course of infestations.

The larvae feed very little during rainy weather but either cling by the claspers and project at an angle from the under surfaces of the leaves or suspend themselves on very short threads. During favourable weather the larvae apparently feed night and day, since the volume of sound produced by the droppings can be heard undiminished all through the night. Of course, this may be due to the larvae getting rid of the food consumed during the day. When the larvae are in the later stages of development, the sound of the droppings resembles a steady, light rain.

During fair weather the larvae often let themselves down on long silken threads, specially when disturbed. In ascending the thread two methods were noted. In one, the larva bends its head back and, reaching up with the back pair of legs, catches the thread higher up. The larva then pulls itself up by straightening out, catching the thread still higher up with the front legs. This process is repeated until the branch is regained, the thread being accumulated in a little ball between the legs and later discarded. In the later stage of an infestation, the woods are festooned with this webbing.

In the other method, which apparently can only be used in travelling along threads already established between two points, the larva loops along the thread in the same characteristic manner that it does along a twig.

The habit of dropping on threads undoubtedly serves as a means of escape from predators and as a means of rapid transference to new feeding locations by dropping from higher to lower foliage, or by dropping to the ground to crawl up some other tree or plant. It may be the means of moving horizontally when the larvae are small. The wind often carries the threads out almost horizontally and could very easily carry young larvae from tree to tree in this manner.

On June 19th, after forty-eight hours of almost continuous rainfall, examination was made to see what effect it had upon the larvae. Instances were noted where maple leaves had been stuck together by the water, drowning larvae between them. Quite a number of larvae were knocked into puddles and drowned and indications were that, over the entire area, the mortality due to the rainfall was considerable.

Pupation

Pupation occurred between August 10th and September 10th. Pupae were not noted in the field in appreciable numbers until August 13th, although a pupa appeared in one of the larval cages on August 2nd. On September 10th there were still a few larvae in the pre-pupal stage and when pupation was at its height there were still some larvae only half grown and a few even smaller. These undoubtedly were overtaken by the winter season or destroyed by some other agency before they became full grown.

The pupa is naked, 7.5 mm. to 11 mm. long and 3 mm. to 3.5 mm. in diameter. The colour of normal pupae varies considerably from light yellowish brown with dark brown pepper spots less distinct. On the wing pads the spots are merged with narrow, brown, interrupted stripes and the spots are more or less in two rows dorsally. The appearance of parasitized pupae will be referred to in the section on parasites.

Pupae were found in moss and crevices, on trunks and limbs of nearly all trees, both conifers and broad leaves. Pupation was also common on the ground beneath the trees and beneath stones, chips, or other protective objects. In severe infestations the ground is covered with them and when so located they are not generally attached to anything. Those on trunks and limbs are held in place by the moss and in addition are attached at the anal extremity.

Adult Emergence

For the study of emergence, 14,500 pupae were used. Of these 7,500 were collected from the southern end of the area which was apparently a year behind the remainder in the development of the outbreak. An additional 7,000 pupae were collected from various parts of the area farther up the river. These two lots were placed in separate cages located in the open forest as nearly as possible under natural conditions.

Moths and parasites were collected each morning and late in the afternoon. Practically all of the moths emerged in the evening and during the night so that most of them were taken in the morning collection. Table 2 indicates the days on which the pupae were collected, the number in each collection, and the emergence of moths and parasites each day.

It will be noted that the males emerged before the females, and that the former outnumbered the latter in both cages. On the southern portion of the area there were 1.8 males to one female, and on the remainder of the area, 2.3 males to one female (Table 2).

The combined emergence of the moths for the two cages has been correlated with weather conditions. It was noted that the peak of the emergence was in the midst of a period of fair weather, with low relative humidity and high temperature.

There was indicated a decided influence of weather conditions on the larval emergence of the parasite, *Winthemia cilitibia* Rand. The only apparent cause for a sudden increase in emergence on September 20th was a definite rise in humidity accompanied by rain. Weather conditions favourable to the emergence of this parasite seem to be the opposite of those favouring moth emergence. The previous high points of emergence were caused by the disturbing of the pupae when collected. Any such disturbance often causes immediate emergence. Note the difference in the figures for parasites and moths in the two cages.

The moths are very quiet during the day, resting on foliage, trunks, limbs, and on the ground, but they rise in clouds when disturbed. In the evening and during the night they fly about actively and gather about lights in great numbers. Copulation apparently takes place soon after emergence, since a number of pairs taken from the cages were *in coitu*. The moths were noticed feeding upon pear cores. In this connection it might be profitable to experiment with traps and baits.

TABLE 2.—CAGE 1—PUPAE FROM STUDY PLOT

Date	Pupal collections	Emergence of males	Emergence of females	Dipterous maggots	Dipterous adults	Hymenopterous adults
Aug. 16	238			3		
Aug. 17						
Aug. 18						
Aug. 19				7		
Aug. 20						
Aug. 21	857			3		
Aug. 22				3		
Aug. 23	1100			12		
Aug. 24	400			10		
Aug. 25				10		
Aug. 26	625			18		
Aug. 27				18		
Aug. 28	800			40		
Aug. 29		1		33		
Aug. 30	500	4		24		
Aug. 31	500	14	1	23		
Sept. 1	2000	16	1	47		
Sept. 2		33	2	16		
Sept. 3		31	1	9		6
Sept. 4		68	7	8		2
Sept. 5		104	16	6		1
Sept. 6	480	139	20	21		3
Sept. 7		182	18	17		4
Sept. 8		237	29	20		4
Sept. 9		291	73	25		2
Sept. 10		332	110	22		3
Sept. 11		391	129	27		4
Sept. 12		304	116	7	1	7
Sept. 13		230	115	8	0	8
Sept. 14		217	122	4	0	6
Sept. 15		127	104	3	0	8
Sept. 16		79	111	3	0	9
Sept. 17		74	167	0	2	6
Sept. 18		50	174	0	1	1
Sept. 19		39	112	0	0	4
Sept. 20		29	79	209	3	2
Sept. 21		8	24	6	0	1
Sept. 22		10	32	0	2	0
Sept. 23		5	14	0	2	0
Sept. 24		12	34	3	3	0
Sept. 25		3	19	3	0	0
Sept. 26		3	6	0	1	0
Sept. 27		3	6	0	1	1
Sept. 28		3	3	0	1	1
Sept. 29		0	4	0	0	3
Sept. 30		1	5	0	1	0
Oct. 1		0	4	0	0	0
Oct. 2		0	0	0	1	1
Oct. 3		0	0	0	0	0
Oct. 4		0	0	0	0	0
Totals	7500	3040	1658	668	19	87

Pupal parasitism—10%
Emergence moths—62.6%
Destroyed by fungus or other cause—27.4%

TABLE 2 (*Concluded*).—CAGE 2—PUPAE FROM THE MAIN AREA

Date	Pupae collections	Emergence of males	Emergence of females	Dipterous maggots	Dipterous adults	Hymenopterous adults
Aug. 16						
Aug. 17						
Aug. 18						
Aug. 19						
Aug. 20						
Aug. 21						
Aug. 22						
Aug. 23						
Aug. 24	225			11		
Aug. 25				0		
Aug. 26	800			12		
Aug. 27				3		
Aug. 28				2		
Aug. 29	700			35		
Aug. 30	1600			130		
Aug. 31				48		
Sept. 1		2		39		
Sept. 2		5		50		1
Sept. 3	1400	3	1	113		1
Sept. 4	1200	11	0	194		0
Sept. 5	800	23	3	238		1
Sept. 6	275	38	2	85		3
Sept. 7		47	2	65		1
Sept. 8		89	7	44		1
Sept. 9		132	14	48		0
Sept. 10		178	19	116		3
Sept. 11		194	36	39		3
Sept. 12		193	34	32		2
Sept. 13		173	38	10		3
Sept. 14		179	52	17		0
Sept. 15		166	65	4		0
Sept. 16		127	56	3		2
Sept. 17		115	63	0		2
Sept. 18		80	59	0		1
Sept. 19		46	51	2		0
Sept. 20		22	30	145		0
Sept. 21		9	9	0		0
Sept. 22		6	13	4		0
Sept. 23		13	25	0		1
Sept. 24		10	49	2		1
Sept. 25		5	48	0		0
Sept. 26		2	23	0		0
Sept. 27		7	25	0		0
Sept. 28		6	18	0		1
Sept. 29		5	21	0		1
Sept. 30		3	24	0		0
Oct. 1		4	6	0		0
Oct. 2		2	8	0	1	0
Oct. 3		0	0	0	0	0
Oct. 4		0	0	0	0	0
Totals	7000	1895	801	1491	1	28

Pupal parasitism—21.7%
Emergence of moths—38.5%
Destroyed by fungus or other causes—39.8%

In 1929 moths continued to fly from August 29th to November 17th. Only a very few moths were found active on the latter date. Shortly after the peak of the moth flight, about September 25th, the waters of the

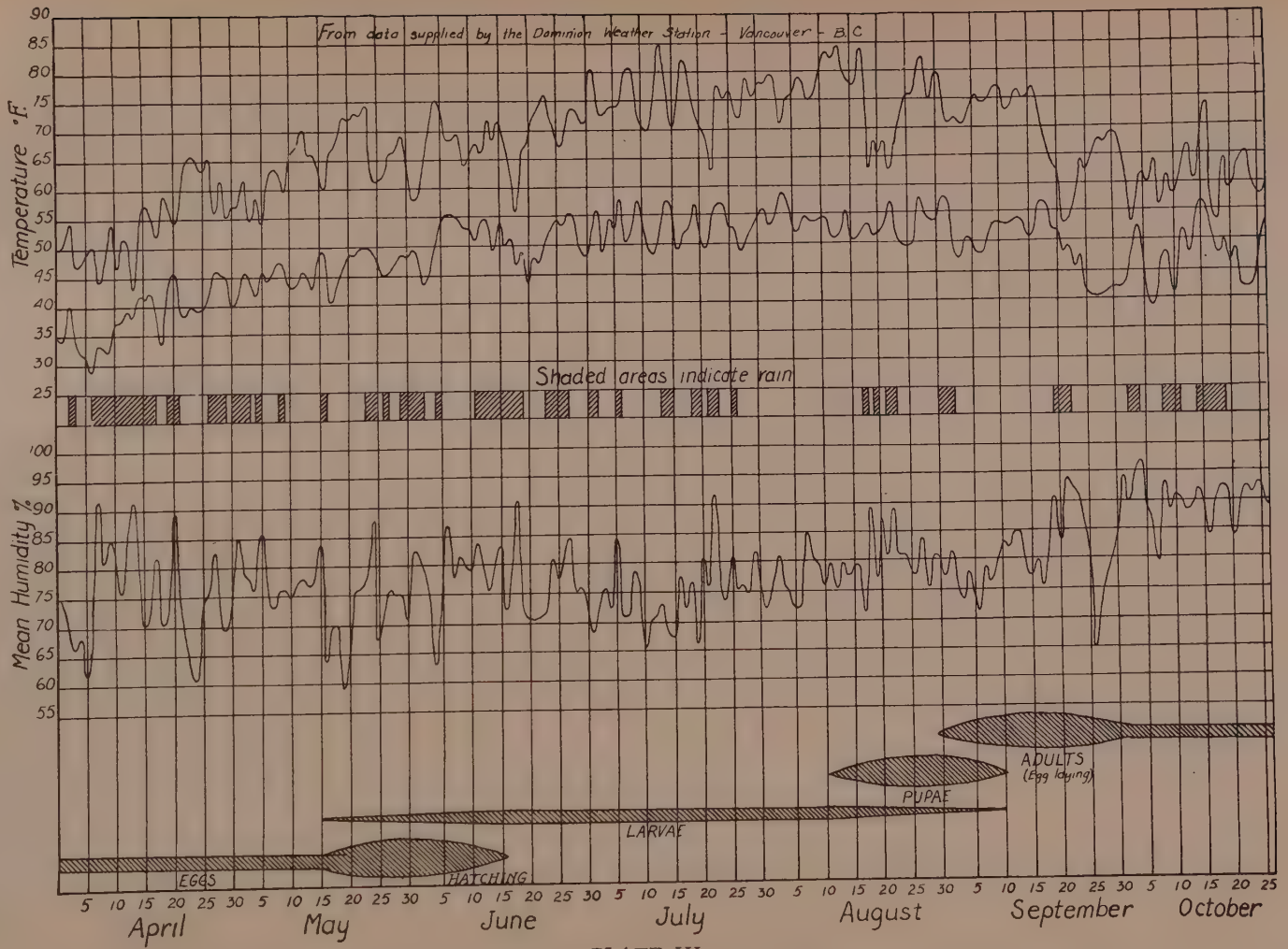

PLATE III

Progress of hemlock looper infestations in the vicinity of Vancouver, British Columbia, 1929.

inlet were covered with moths for a distance of three miles. Plate III indicates weather conditions from the time of hatching up to the time the moths had practically disappeared.

CONTROL

Parasites

The following parasites have been bred from some stage of the western hemlock looper in British Columbia:—

Diptera: *Winthemina cilitibia* Rand.
Zenillia blanda O.S.
Agria affinis Fallen.

Hymenoptera: *Amblyteles cestus* Cres.
Amblyteles sp., near *velox* Cress.
Apechthis ontario Cress.
Ephialtes (Itoplectis) obesus Cush.
Ephialtes sp.
Hemiteles sp. (hyper-parasite?)
Hyposoter sp., near geometrae Ashm.
Gelis ferruginosus Cush. (hyper-parasite).
Ichneumon sp., probably *puerilis*.
Telenomus sp., near *dalmani* Ratz.
Mastrus neodiprioni Vier. (hyper-parasite?).

Fungi: *Empusa rhizospora*.
Sporotrichum globuliferum Sperg.

The most effective parasite of the hemlock looper larvae in British Columbia is the Tachynid fly, *Winthemia cilitibia*. Under field conditions, emergence took place in 1930 as indicated in Table 3. Five hundred pupae were used.

TABLE 3.—EMERGENCE OF ADULTS OF *Winthemia cilitibia* RAND

June 23	24
June 28	32
June 30	60
July 7	81
July 11	96
July 18	26
July 26	2
Total	321 adults

The egg is deposited on the dorsum of the looper larva just behind the head or a short distance from it. Cases have been noted where eggs were deposited on the venter and behind the middle of the body. The young larvae penetrate the body of the host, gradually moving posteriorly as the host develops. It is therefore not difficult to distinguish parasitized larvae in the later stages by the noticeable posterior swelling. The larvae of the parasite emerge from the pupal cases of the host and enter the soil or forest duff where they remain all winter, pupating the following spring.

From 7,000 looper pupae, 1,491 *Winthemia cilitibia* larvae emerged between August 24th and September 24th. In another lot of 7,500 pupae, 668 larvae emerged during the same period. The influence of weather conditions on the emergence of the parasite larvae has been noted. In one instance, three fly larvae were found in one pupal case and in several instances two were found in one pupal case. Cases of double and triple occupancy did not appear numerous enough, however, seriously to affect the figure for the percentage of parasitism.

Another parasite of considerable importance is a species of *Hyposoter* which destroys the looper larvae before the latter pupate. When full grown the parasite larvae pupate and drop to the ground, where they may be found in considerable numbers beneath the trees. They often flip and roll about in the manner of Mexican jumping beans. The pupal cases are very tough, light gray when first formed, turning almost black later. They are ovoid, 4.5–6 mm. long, and 2.5–3 mm. in diameter. Adults emerged under laboratory conditions in November. One thousand of these pupae were collected and sent to Ottawa for study.

Seventy-one specimens of *Amblyteles cestus* Cress. emerged from looper pupal cases between September 3rd and September 29th under field conditions. This parasite was also bred from the oak looper of Vancouver Island by Dr. James Fletcher (*2*).

Eight specimens of *Amblyteles* sp. near *velox* Cress. emerged under field conditions from hemlock looper pupal cases between September 9th and September 30th. The place of oviposition was not determined.

Thirty-two specimens of *Apechthis ontario* Cress. emerged from hemlock looper pupal cases between August 31st and October 2nd under field conditions.

One looper larva was found parasitized by a species of *Braconid.* There were thirteen parasite larvae attached to one host which was much swollen and pale yellowish green in colour. An attempt to rear these parasites was unsuccessful.

Four specimens of *Telonomus* sp., near *dalmani* Ratz., emerged from hemlock looper eggs on June 7th, 1929, and six more on February 17th, 1930. In the spring of 1930, 705 looper eggs were collected and 181 specimens of the same parasite were recovered from this lot. This indicated an egg parasitism of 25% on the Seymour area and indicates that this parasite is sometimes an important factor in the control of outbreaks.

In addition to the above parasites, a few specimens were taken of *Mastrus neodiprioni* Vier., three of *Gelis ferruginosus*, (wingless), four of *Ephialtes* (*Itoplectis*) *obesus* Cush., one of *Ephialtes* sp., and three *Ichneumon* sp., probably *puerilis* Cress., *Hemiteles* and *Gelis* are probably secondary parasites on *Hyposoter.*

The pupae containing the larvae of *Winthemia cilitibia* Rand. are easily recognized by the dark brown colour in which the pepper spots are barely visible or have been submerged. They are also soft to the touch and easily ruptured, releasing a foul smelling fluid. When disturbed the maggot often emerges shortly afterwards. This accounts for the large emergence which took place with each collection of pupae. At the end of half a day's work the collecting can was often squirming with maggots.

The looper pupal cases containing the Hymenopterous parasites look much like normal pupae except that some of them are longer and larger and have a less solid appearance. The case is often rigid.

Two species of fungi were found to destroy the hemlock looper. The most common one was a white mould which sometimes occurred where the pupae were thickly placed in moss on the shady side of trunks. The species has not been identified.

PLATE IV

FIGURE 1—Indian River Valley, location of a severe hemlock looper outbreak.
FIGURE 2—Group of hemlocks killed by the western hemlock looper.
FIGURE 3—Stand of timber killed by the western hemlock looper.

PLATE V

FIGURE 1—Airplane dusting, Seymour Canyon.

FIGURE 2—Experimental airplane dusting—Wigwam Inn, showing dust settling over foliage after passing of the airplane.

Of the other fungus, only one specimen was secured. This was a dead larva with finger-like pseudo-conidia projecting from it. Judging from this single example, Dr. H. T. Gussow believed it to be *Empusa rhizospora*.

Dr. James Fletcher (*2*) mentions a fungous disease prevalent in the oak looper infestations on Vancouver Island. He says it attacked the insects in all stages of development. It was identified by Professor Roland Thaxter as *Sporotrichum globuliferum* Spegazzini.

Predators

Only one instance was noted of an insect feeding upon a looper larva. This was a Hemipterous nymph which has not been determined. Several instances were noted of large black wood ants dragging looper larvae along.

On July 8th, a young yellow warbler *(Dendroica aestiva* Gmelin) was discovered in a vine maple bush. The old bird was stuffing looper larvae down the young one's throat as fast as she could collect them. She only had to fly a few feet from her offspring to collect a billfull. The young one's capacity seemed unlimited, since it readily took all of the food supplied during fifteen minutes of observation.

On July 18th a junco *(Junco hyemalis oregonus* Townsend) was seen to eat looper larvae from a broad leaf maple.

On July 19th a number of chick-a-dees *(Penthestes rufescens?)* were observed for some time as they fed voraciously upon looper larvae. At least two other species of birds were seen to feed upon the larvae, one of which was apparently a kinglet and the other the white crowned sparrow *(Zonotrichia leucophrys* Forster). The above determinations were made from field observations only. It would be profitable, no doubt, to make an examination of the stomachs of various birds in an infested area.

Control by Airplane Dusting

At the present time airplane dusting offers the only feasible method of direct control of defoliators over large forest areas. Before discussing actual control operations it may be well to point out some of the problems to be considered in undertaking an airplane dusting project.

The first is, naturally, the selection of a suitable airplane. The choice must be governed largely by the character of the dusting project contemplated. In Ontario, a tri-motored plane, capable of carrying a pay load of 1,000 to 1,500 lbs., has been found much more satisfactory than a single motored plane or one of smaller capacity. If, however, the terrain is rough, with narrow canyons, a smaller type of plane would probably be less hazardous. In such cases it might be advisable to use several of the small planes to make up for the reduction in carrying capacity.

Another very important item is the selection of a landing field. Most flying concerns charge by the flying and waiting hour, and accordingly the flying bill varies directly with the distance to and from the landing field. The type of landing field also determines the type of landing gear the plane must carry. If on water, the plane must, of course, be equipped with pontoons.

Speed of execution is absolutely essential, aside from the fact that it reduces the cost, for good dusting weather is often of short duration and fullest advantage must be taken of it. Dusting of course cannot be done

in rainy weather or if there is a probability of rain within twenty-four hours. Greater success will be attained if there is no rain for at least one week after dusting.

Wind is another serious obstacle to good dusting. Although a side drift of four or five miles per hour is more desirable than so-called dead calm air, a wind of over ten miles per hour carries the dust too far from the line of flight, causing patchy, insufficient coverage. Ideal dusting conditions are present when there is a high humidity, dew on the foliage, and a side drift of three or four miles per hour, at right angles to the line of flight. The time of day when these conditions are present or approached varies with different localities. In some places, early morning hours are found to be the best, while some workers have found the evening to be better suited to the work. Careful consideration of weather conditions is therefore necessary and it is a good plan to keep in touch with the nearest weather station.

If possible, the plane should never fly more than fifty feet above the tree tops when dusting, and preferably about twenty-five feet. Under ordinary conditions, the flight lines can be 150 feet apart to obtain a coverage of eighteen to twenty pounds per acre. To accomplish this, the hopper must be regulated to deliver 375 to 400 pounds per mile.

On areas where there are no good guide lines already established to aid the pilot, it is sometimes necessary to mark out a base line by placing flags in the tops of trees at the beginning of every fourth flight line. It has been found that red or white flags are seen most readily from the air, the white being slightly better. The dusting strips are flown perpendicular to the base line. Ridges, streams, valleys, roads, power lines and shore lines may serve as guide lines upon which to base the lines of flight.

Even after the most careful plans have been made, and with the best of luck in the matter of favourable weather, a large part in the success of a project is due to the skill and judgment of the pilot. When possible, it is desirable to engage pilots with previous dusting experience. Problems are sure to arise, peculiar to each operation, which cannot be foreseen, and which must be dealt with as they are encountered.

Wigwam Inn Project.—The first airplane dusting project in British Columbia was undertaken in 1929 at Wigwam Inn, Burrard Inlet. There were several urgent reasons for doing this work. In the first place, it was advisable to demonstrate the feasibility of airplane dusting to timber owners and to the officers of the Provincial and Dominion Forest Services. It was realized that other infestations would probably appear and that all information possible should be obtained as to how to deal with them. Secondly, it was desirable to show the effectiveness of the calcium arsenate dust in killing the looper larvae. Thirdly, Wigwam Inn is a summer resort valued at not less than $100,000 and it was extremely desirable to preserve the scenic beauty of the immediate Inn surroundings, irrespective of timber values involved. All of those interested were frankly sceptical of the value of the dusting and consequently were unwilling to risk any large sums of money. It was therefore necessary to limit the project to a small experimental area of forty-five acres in the immediate vicinity of the Inn, in the hope that this timber would be carried through the peak year of feeding with a minimum of damage.

The type of plane used was a Boeing flying boat driven by a 420-horse power Wasp motor.

The dust used was commercial calcium arsenate, one part to six of hydrated lime. Twelve hundred pounds of dust proved sufficient to secure the desired coverage of 26 pounds per acre. The dust was put up in paper bags of 25 pounds each and shipped in barrels. These were stored in the basement of the Inn until ready for use. The basement is on the ground level and since the Inn is situated on the beach, it was not difficult to wheel the barrels down to the float fast enough to supply the plane during the operation.

The hopper used was 2 feet by 2 feet in cross section and 2 feet 10 inches high. It was constructed of galvanized sheet metal reinforced by heavier iron strips at the corners and tapered beneath to a round aperture 11 inches in diameter. An agitator was mounted 8 inches above the throat and consisted of an iron rod with several deep undulations. The outer end of the rod was fitted with a crank for hand operation. Release of the dust was controlled by a sliding gate. The hopper was placed inside the cabin of the plane and the dust released through the floor.

The stand of timber dusted is situated on the west side of the inlet, on a bench sloping gently back from the beach for 1,200 feet, after which the high mountains rise steeply. The composition of the stand has already been noted. It is mostly mature timber with a few old spike top cedars projecting above the general canopy level, making flying more hazardous.

Several causes contributed to delay the actual dusting operation. The weather was the main source of worry. The spring and early summer of 1929 were exceptionally rainy.

The first dust released was a trial load of 200 pounds delivered on the evening of July 30th. Weather conditions were good, calm with a slight southerly drift. On the following morning dusting was resumed at 8.30 a.m., and by 11.30 all of the dust had been delivered. At ten o'clock a slight breeze sprang up from the south which had increased to a velocity of about eight miles per hour by the time the dusting was completed. This materially aided in securing a better distribution. The cost of the operation was as follows:—

Hopper, material and labour	$ 52.92
Calcium arsenate, 1,400 lbs.	63.00
Express on dust	45.64
Freight, Vancouver to Wigwam Inn	9.00
Western Canada Airways	301.00
Total	$471.56

This cost should not be considered on a per acre basis, because the value of the timber, as such, was not involved. It must be remembered that this project was an emergency operation, organized and completed in less than one month.

After the dusting, the looper larvae had two full days of ideal feeding weather. It was clear, calm, and warm. On August 2nd the larvae commenced to drop from the trees in great numbers and the ground beneath severely infested trees was crawling with them. These showed the effects of poisoning, *i.e.*, sluggishness at first and later an apparent paralysis.

When the affected caterpillars fall the tendency is for them to climb again and in so doing hundreds died on the tree trunks and in great masses at the tops of stumps and snags. The counts shown in Table 4 were made beneath severely infested trees.

TABLE 4.—LARVAL COUNTS AFTER DUSTING

August 3—One sq. yd. beneath large maple	132 dead
August 3—One sq. yd. beneath large hemlock	51 dead
August 3—One sq. yd. beneath large hemlock	234 dead
August 5—One sq. yd. beneath large hemlock	354 dead
August 5—One sq. yd. beneath large hemlock	631 dead

These figures merely indicate that a great number of larvae were killed by the dusting but do not indicate the percentage of mortality. The estimation of the percentage of mortality after dusting is a difficult matter. Some of the methods used in the past are the following:—

1. Placing square yard pieces of cloth beneath branches and counting the number of dead larvae on them each day, both before and after dusting. Comparisons are then made with the number of live larvae which were on similar branches before dusting. This method is inaccurate because many of the larvae crawl considerable distances before dying and therefore crawl off the cloth.

2. Comparison of the number of live larvae shaken from twigs of similar size and under similar conditions before and after dusting. This method is also inaccurate because it assumes that the limbs compared were equally heavily infested, which may or may not have been the case.

3. A method which is fairly accurate for young even-aged stands is that employed in one dusting operation in Ontario. Four or five representative trees were delimbed over 20 foot square pieces of canvas both before and after dusting. All of the larvae were counted in each case and comparisons made. The main objection to this is that it is a slow and laborious process, entailing considerable expense and only suited to a particular type of stand. For most stands in the Northwest it is entirely out of the question.

It is thought that a better method might be worked out by placing square yard pieces of muslin stretched on frames at a number of representative situations on the area. A comparison of the density of the daily droppings might then be made for several days before and for two weeks after the dusting. The effectiveness of the dusting could then be calculated by the reduction in the amount. This method has been employed extensively in Europe.

Stanley Park Project.—In the fall of 1929, the presence in Stanley Park of adults of the western hemlock looper and the hemlock tip moth in considerable numbers indicated that heavy defoliation of the hemlocks would probably occur during the summer of 1930, unless control measures were undertaken. Defoliation was noted in a number of places in 1929, but not severe enough to kill any trees. A survey of the area was made in the fall of that year and the areas of defoliation indicated on the map. The situation was then presented to the proper city authorities and they were urged to undertake the dusting of the park in the spring of 1930.

The Western Canada Airways again undertook the contract to do the flying. Three Boeing flying boats were used, equipped with an entirely different type of hopper than the one used at Wigwam Inn. The arrange-

ment consisted of twin hoppers in the form of a saddle which fitted over the hull. The dust was discharged from both hoppers simultaneously and was released by means of a lever at the pilot's right hand. The pair of hoppers held 500 pounds of dust.

In order to insure as even a feed at the end of the delivery as at the beginning, a false bottom was put on the inclined side of the hopper, within. This was hinged at the bottom and a tension spring attached across the top. As the weight of the load decreased, the tension spring gradually pulled this panel into a vertical position so that all of the dust would be delivered and at a fairly even rate of flow.

Stanley Park occupies a peninsula of 1,000 acres but it was only necessary to cover 800 acres with dust. The stand consists of 70% hemlock, 20% Douglas fir, and 10% western red cedar. The tract is divided into smaller areas by trails and roads which served as excellent guide lines for the pilots, since these areas could be recognized from the air. The correct amount of dust for each area had previously been calculated and marked on the map.

Dusting commenced at 4 a.m. on June 15th. The entire supply of dust, gas, and oil had been loaded on to a scow the previous night. At 3 a.m. the scow was towed into Vancouver Harbour and located so that there was just room enough between it and the park for a good take-off and landing. The distance flown to and from the loading scow was thus minimized.

A tug was in attendance at all times so that the scow could be kept in proper position. The 50-pound bags of dust were placed around the edge of the scow against the uprights, in lots sufficient to fill each hopper. The planes flew in rotation as much as possible in order to facilitate loading and refuelling.

Officers of the Dominion Entomological Branch maintained communication with the pilots by means of a fast launch which travelled between the main park entrance and the scow. An automobile was kept at the entrance so that most parts of the park could be reached in a few minutes and the distribution of the dust checked.

Difficulties were increased by the number of spike top cedars which extend far above the general forest level. In some instances the pilots flew below these, skilfully avoiding them. This may not have been possible with larger machines.

The required eight tons of dust had been delivered by 10 a.m. Dusting conditions were ideal. There was very little wind, just enough drift to aid in securing a better distribution. During the early part of the dusting, the dew was quite heavy on the leaves, causing the dust to adhere very readily. The dust distribution was checked by examination of the leaves of deciduous trees beneath the conifers. The coverage obtained was from 18 to 20 pounds per acre. The cost of the operation was as follows:—

Western Canada Airways		$5,500.00
8 tons calcium arsenate		720.00
Freight on dust		144.00
Hire of Launch		30.00
	Total	$6,394.00

If based on the actual area dusted, the cost per acre was $7.96. The cost per acre of a similar project in Peninsula State Park, Wisconsin, in 1926, was $7.04. Barnes (*1*) gives an average cost per acre of $15.50 in dusting for the control of gypsy moth. Swaine (*4*) quotes an estimated cost of $6.00 per acre in dusting for the control of the hemlock looper in Quebec Province.

Seymour Project.—A similar dusting operation was carried out on the Seymour Watershed on June 19th. All of the flying arrangements were the same as described above, but the actual execution of the work was far more difficult because of the situation of the area.

Seymour Canyon is narrow, with steep walls, and is eight miles air line from tide-water. The length of the dusting strips was two miles. Each plane therefore flew twenty miles in delivering a load. There were thirty-two trips made, making the mileage flown to and from the area 640. About twenty-five miles can be added for taking off and reconnoitering and another twenty-five miles for turning, making a total of 690 miles flown. Dusting commenced at four a.m., and was completed at four p.m. Eight tons of dust were used.

The success of these two operations was gratifying to all concerned. It was estimated that in the case of the Stanley Park area, from 75% to 85% of the larvae were destroyed, and on the Seymour area, from 80% to 85%. Even under the most favourable circumstances it is extremely difficult to obtain a reliable mortality figure when the larvae are so small.

At the time of dusting the second moult had not occurred for the majority of larvae. The importance of this is apparent from the following considerations.

It had been previously noted that the emergence of the parasite, *Winthemia cilitibia* Rand, occurs between June 20th and July 20th, with the peak about July 11th. Observations in the field have shown that the majority of eggs are deposited after the third moult of the host. This occurs after July 7th for the majority of larvae. Therefore, if dusting is done during the later stages, many parasites are destroyed with the larvae, but if done during the early stages, before June 30th, the looper larvae are not only more easily killed, but the parasites later deposit eggs on those that escape the dust, and the natural increase of the parasite is not disturbed except by the limitation of food supply.

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Résumé

L'attaque de l'arpenteuse de la pruche de l'ouest, *Ellopia somniaria* Hulst, sur les conifères de la Colombie-Britannique. G. R. Hopping, Laboratoire fédéral de l'entomologie, Vernon, C.-B.

De 1928 à 1930, plusieurs foyers considérables de l'arpenteuse de la pruche de l'Ouest, *Ellopia somniaria* Hulst., ont été signalés sur le littoral de la Colombie-

Britannique. Une de ces invasions a été étudiée sur la Rivière des Indiens, le bras nord de l'anse Burrard. Les notes suivantes ont été prises sur le cycle évolutif de l'insecte:

L'insecte parfait fait son apparition et pond ses œufs en septembre. Les œufs éclosent le printemps suivant, vers la fin de mai ou le commencement de juin. Les larves sont actives entre la fin de mai et le commencement de septembre. La chrysalide, ou pupe, se voit entre le 10 août et le 10 septembre.

Cette arpenteuse est exposée, dans ses différentes phases, aux attaques de trois parasites diptères et de huit parasites hyménoptères. Les plus agressifs de ces parasites sont les suivants: *Winthemia cilitibia* Rand., esp. *Hyposoter*, proche de *geometrae* Ash., *Amblyteles cestus* Cresson et esp. *Telenomus* proche de *dalmani* Ratz. Plusieurs espèces de champignons causent parfois une mortalité considérable et certains oiseaux de proie jouent également un rôle utile dans la répression du fléau. Les conditions de température entrent également en ligne de compte.

Un essai de saupoudrage par la voie des airs, démontrant que les moyens répressifs artificiels peuvent être utiles, a été conduit à Wigwam Inn, Burrard Inlet, en 1929. En 1930, deux opérations de saupoudrage par aéroplane, couvrant une étendue de 800 acres chacune, ont été conduites dans le Parc Stanley et sur le versant Seymour, d'où Vancouver reçoit ses eaux d'approvisionnement. Ces deux opérations ont réussi à enrayer l'invasion de l'arpenteuse de la pruche dans ces districts.

STUDIES OF SOLID STEM WHEAT VARIETIES IN RELATION TO WHEAT STEM SAWFLY CONTROL

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Sawfly injury to wheat in Western Canada is noticeable from the stems which apparently break off near the base and fall to the ground. The actual injury arises from the operation of the sawfly larvae which sever or partially sever the stems about one inch above the ground in preparation for their hibernation. Because of the existence of wheats with pithy stems the possibility of these in offering resistance to the activities of actual sawfly larvae has been studied.

Saskatchewan Provincial Statistics indicate that the damage to the wheat crop caused by sawfly is considerable and widespread. Estimates for the Marquis wheat area of Saskatchewan, which includes crop districts Nos. 1 to 7, show that sawfly damage for the years 1927 to 1932 averages 4% of the total yield, which is equivalent to a loss of about seven million bushels of wheat per year. The loss caused by sawfly damage in crop districts 3 and 4 for the same period is heavier than in others, being 5.5%. The damage is not evenly spread over the affected area. In some fields, or portions of fields, the grain is much more heavily infested than in others. Damage in some fields exceeds 50%, so that the loss sustained by individual farmers is often serious.

Marquis wheat appears to be highly susceptible to sawfly damage. Coupled with this is the fact that the greater portion of the Marquis wheat area is the natural habitat of the sawfly. These two factors together appear to serve to perpetuate the annual damage caused by the pest.

OCCURRENCE OF SOLID OR PITHY CHARACTER IN WHEAT

Nearly all the wheat grown in Western Canada possesses the hollow stem character. Stems of wheat varieties may be either solid, semi-solid or hollow. The solid character of wheat stems is generally regarded as referring to the presence of "pith" inside the stems. The amount of "pith" or the percentage of the wheat stem that is filled with "pith" varies with different varieties or strains. A hybrid between a hollow stem parent and a solid stem parent may produce intermediate types with stems which are partly solid and partly hollow. Biffen (*1*) crossed Turgidum (solid stem) and Vulgare (hollow stem) and found the F_1 stems to be hollow, but a splitting occurred in the F_2 generation in the ratio of three hollow to one "pithy" or solid. Engledow (*2*) reported similar results in 1923 with Polish (solid stem) and Kubanka (hollow stem) crosses, except that he found considerable variations of the pithy content in the F_3, F_4 and F_5 families. Stems that are filled with pith from the base of the spike to the crown of the root are said to be solid. Stems that are partly filled with pith and partly hollow are regarded as being semi-solid. The amount of pith found in semi-solid or intermediate types of stems can naturally vary quite widely, since a semi-solid stem may be less solid at only one part of

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an internode, or it may be filled with pith except in a small portion of an internode, usually just below the base of the spike.

Engledow (*2*) says: "It is to be expected that solidness of straw is not morphologically a simple character. Not only the presence of a greater or less amount of pith, but also the girth and other characteristics of the surrounding wall of the straw, must determine the relative solidness." These characteristics, together with other features peculiar to solid wheat stems, appear to offer various restrictive means by which reproduction of the wheat stem sawfly is considerably diminished or controlled.

Observations at Swift Current, 1929

A solid stem wheat such as Golden Ball and a semi-solid wheat as White Straw Tuscan, were not as seriously affected by sawfly injury as were the hollow stem varieties. Examination of solid stems indicated that, while some were infested, the sawfly larvae in most cases had destroyed only a small portion of the inner parts of the culm, and further, that the larvae did not penetrate the nodes of solid stems or solid portions of semi-solid stems in the direction towards the base of the plants. It may therefore be assumed that solid stem wheat varieties offer a possible means of controlling sawfly damage.

Control appears to be dependent on the following conditions:

(1) Would sawflies lay eggs in solid stem wheats?

(2) If the eggs were laid would they hatch and develop into normal larvae?

(3) If the larvae were trapped in the internodes of solid stems, could they be destroyed if the stubble, cut high by a header or a combine reaper thresher, were burned; or infested straw in stacks disposed of by the same means.

(4) Could the larvae sever the stems of solid stem wheat?

(5) Should the larvae in solid stem wheat reach the base of the plant, would their development be so impaired that they could not survive the winter?

EXPERIMENTS

Preliminary Tests, 1930.—Two heads of semi-solid wheat C.I. 7265-12, of Egyptian origin, were obtained from the United States Department of Agriculture for further tests. The seed was sown in two head rows in 1930. Many of the stems of the resulting crop were found to be hollow and infested with sawfly larvae. A number of solid stem plants were found and these were mainly unmolested. Heads from selected solid stem plants were used for increase of seed and further observation in 1931. Plants with solid stems, semi-solid stems and hollow stems were produced. Solid stem plants were only slightly damaged as in 1930.

Forced Infestation Tests, 1931.—In 1931, plants of Golden Ball and C.I. 7265-12 were caged and subjected to forced infestation, in order that all the plants in the cages would be subjected to sawfly attack. A large number of adult sawflies, previously hatched from wheat stubble, was placed in the cages at the normal egg-laying period for this purpose. The stems of the Golden Ball plants which were examined were found to be uniformly solid from the crown roots to the base of the spike and showed

only a slight infestation and complete immunity to severing by the sawfly larvae. Solid stems of C.I. 7265-12 were also very slightly infested. The hollow parts of semi-solid stems were considerably infested, but the downward movement of the larvae towards the base of the plant was invariably checked at the first node encountered in the solid, pithy part of the culm. Practically all of the hollow stems were severed at about one to two inches above the ground.

Forced Infestation Tests, 1932.—In 1932, seven varieties were subjected to forced infestation under cages. Solid or semi-solid varieties, were represented by Golden Ball and C.I. 7265-12 respectively. Marquis, Reward, Reliance, Hope and Ceres represented the hollow stem varieties. Adult sawflies, hatched out of Reward and Marquis wheat stubble, were introduced into the cages at the normal time of sawfly emergence. A large percentage of the stems of C.I. 7265-12 were hollow, and these were nearly all severed by the sawfly larvae, which, in some measure, accounts for the high percentage of damage as shown in Table 1. Most of the solid stems were only slightly damaged. Golden Ball, though infested to the extent of 18%, was resistant to severing. The Hope variety was only lightly infested with slight injury. Ceres also, shows little damage from sawfly, but it is known that this variety is of somewhat weaker straw than Marquis, and for that reason it is uncertain that Ceres may be regarded as strongly resistant to sawfly. The low percentage infestation of Ceres and Hope may be due to unsuitable development of the plants at the time of oviposition under unnatural forced conditions. Further observations are necessary to determine this point.

TABLE 1.—RESULTS OF FORCED SAWFLY INFESTATION OF WHEAT VARIETIES UNDER CAGES—YEAR 1932—DATA BASED ON EXAMINATIONS OF STEMS COLLECTED AT HARVEST

Variety	Stems not infested, %	Stems infested, %	Stems severed, %
B.P.I. C.I. 7265-12, in small cage	25.2	74.8	53.9
B.P.I. C.I. 7265-12, in large cage	13.1	86.9	58.1
Ceres	92.8	7.2	2.1
Reliance	89.4	10.6	7.0
Reward	83.5	16.5	8.2
Marquis 10B	82.2	17.8	13.4
Hope	95.8	4.2	3.4
Golden Ball	82.0	18.0	Nil

Winter Survival.—To determine the percentage of winter survival of sawfly, and whether the character of the stems exerted any influence on the winter mortality of the larvae, samples of stubble from the seven varieties used in the 1932 Forced Infestation Test were gathered from each plot during the following spring and placed in metal containers under suitable temperatures to await emergence of the adult sawflies. Numbers of the stubbles examined, percentage of the stems found to be infected, the percentage of the stems actually cut by the larvae and the percentage that survived the winter are shown in Table 2. Though Golden Ball was infested 18% in 1932, no adult sawflies emerged in 1933. Emergence of

adults from 14.3 to 45% were obtained from all other varieties on this test. Thus, Golden Ball escaped heavy infestation, suffered very little damage by internal boring and severing of the stems and supplied no adults to continue the life cycle. Ceres and Hope, hollow stem sorts, produced a survival of sawfly larvae and emergence of adults equal to 14.3 and 18.8% respectively. Though the survivals from these varieties were considerably higher than that of Golden Ball solid stem which was nil, their percentages were also very much lower than all other varieties in the test.

TABLE 2.—INFESTATION AND WINTER SURVIVAL OF SAWFLY LARVAE IN STEMS OF CAGED WHEAT VARIETIES*, 1932-1933

Wheat—Variety	Number of stubbles examined	Per cent of stubble infested by *C. cinctus*	Per cent cut by *C. cinctus*	Per cent survival
B.P.I. C.I. 7265-12, in large cage	282	70	57	30.4
B.P.I. C.I. 7265-12, in small cage	99	75	68	40.3
Ceres	102	28	6	14.3
Golden Ball	83	1	0	0
Hope	110	15	4	18.8
Marquis 10B	86	29	22	44.0
Reliance	101	20	11	45.0
Reward	98	29	16	28.6

* The percentage of the total number of stems, infested and cut by *C. cinctus*, was determined by actual examination of the collected stubble after emergence of the sawflies had been completed. The percentage listed as cut is that of the total number of stems rather than that of the number infested.

NATURAL INFESTATION TEST, 1932

Experiments with 38 Varieties or Strains of Solid Steam Wheats. —The 38 varieties or strains of solid stem wheat used in these determinations were obtained from Dr. O. Frankel, Lincoln College, Christchurch, New Zealand. Two of the varieties originated in New Zealand, the remainder were obtained by the Lincoln College from Spain, Portugal and Morocco. All the 38 varieties were subjected to natural infestation. In addition to examining the stems for sawfly damage, 250 stems of each variety were examined to determine the extent of the solid character and pithiness of the stems (See Table 3). For convenience, the extent of pithiness was determined by using the nodes as an index. Stems, solid from the ground to the first node above ground, were listed in the first node column. Stems, solid to the second node, were listed in the second node column and so on. In addition, the number of stems infested was noted for each "node" group. A high percentage of all the varieties were solid to the fifth node, which indicates that the stems were entirely solid from the roots to the spike. The percentage of infestation was also low for many of the varieties. The percentage severed was from nothing to slight for all the varieties. Varieties S-378 and S-835 had a large percentage of hollow stems. These were found to have very thick walls, which was regarded as the probable reason why these varieties were not more severely infested or severed. Marquis wheat, and other hollow stem varieties sown at the same time, were considerably damaged by sawfly.

TABLE 3—SOLID STEM CHARACTER OF WHEAT IN RELATION TO SAWFLY INFESTATION AND DAMAGE

ROD-ROW TEST PLOTS OF WHEAT VARIETIES INTRODUCED FROM NEW ZEALAND

DATA BASED ON EXAMINATION OF 250 STEMS

All Varieties subjected to Natural Means of Infestation

S.C. Ac. No.	Variety No.	Number of stems showing solid character from the crown to the various nodes and the number in each group infested by sawfly larvae												Total stems not infested, infested or severed out of 250 stems examined					
		Stems hollow throughout		1st node		2nd node		3rd node		4th node		5th node		Number of stems not infested	Number of stems infested but not severed	Number of stems infested and severed	Per cent infested	Per cent severed	Remarks
		Hollow	Infested	Solid	Infested	Solid	Infested	Solid	Infested	Solid	Infested	Solid	Infested						
350	Solid Straw	—	—	—	—	—	—	4	—	4	—	242	8	242	7	1	3.2	0.4	
352	Tuscan S—373	—	—	—	—	—	—	14	—	16	—	220	22	228	20	2	8.8	0.8	
353	S—374	—	—	1	—	2	—	10	—	20	—	217	6	244	5	1	2.4	0.4	
354	S—377	3	2	3	—	7	—	74	5	133	20	30	—	223	25	2	10.8	0.8	Very thick walls.
355	S—378	130	8	58	—	19	10	37	—	6	1	—	—	231	19	—	7.6	—	
357	S—386	3	2	5	—	3	—	25	3	61	12	155	13	220	28	2	12.0	0.8	
359	S—493	—	—	—	—	6	—	4	—	5	—	235	2	248	2	—	0.8	—	
361	S—615	—	—	—	—	1	—	3	—	2	—	240	4	246	4	—	1.6	—	
362	S—617	—	—	1	—	5	—	25	—	34	3	185	30	217	28	5	13.2	2.0	
363	S—618	6	—	5	—	5	—	4	—	11	—	219	45	205	45	—	18.0	—	
364	S—630	—	—	—	—	—	—	2	—	17	—	231	22	228	22	—	8.8	—	
365	S—632	1	—	—	—	—	—	2	—	4	—	243	1	249	1	—	0.4	—	
366	S—663	3	1	—	—	1	—	8	—	2	1	236	20	228	22	—	8.8	—	
367	S—635	—	—	—	—	1	—	6	—	19	4	224	39	207	34	9	17.2	3.6	
368	S—639	—	—	—	—	—	—	5	—	5	—	240	55	195	55	—	22.0	—	
369	S—668	—	—	1	—	—	—	3	—	10	1	236	1	248	2	—	0.8	—	
370	S—671	2	—	—	—	1	—	8	—	41	7	198	34	209	41	—	16.4	—	
371	S—673	—	—	—	—	—	—	4	—	105	37	141	9	204	40	6	18.4	2.4	
372	S—683	—	—	—	—	—	—	1	—	3	—	246	60	190	43	17	24.0	6.8	
373	S—684	1	—	—	—	—	—	3	—	4	—	242	87	163	80	7	34.8	2.8	
374	S—691a	—	—	—	—	9	—	14	—	3	—	224	14	236	14	—	5.6	—	

374	S—691b	7	—	11	—	4	—	20	2	11	—	197	10	238	10	2	4.8	0.8	
*374	S—691c	5	—	1	—	6	—	11	—	6	—	41	5	65	4	1	7.1	1.4	
†374	S—691d	3	—	—	—	—	—	4	—	—	—	43	4	46	4	—	8.0	—	
375	S—700	—	—	—	—	—	—	3	—	17	—	230	8	242	7	1	3.2	0.4	
376	S—702	—	—	—	—	1	—	1	—	17	3	231	34	213	36	1	14.8	0.4	
377	S—707	—	—	1	—	10	—	217	37	15	—	7	—	213	37	—	14.8	—	
378	S—717	—	—	—	—	—	—	2	—	—	—	243	98	152	81	17	39.2	6.8	
379	S—736	—	—	—	—	3	—	28	4	160	2	59	—	244	6	—	2.4	—	
380	S—767	—	—	1	—	3	—	15	—	81	39	150	18	193	54	3	22.8	1.2	
381	S—771	—	—	—	—	1	—	2	—	—	—	247	1	249	1	—	0.4	—	
382	S—778	—	—	—	—	—	—	16	—	35	5	199	26	219	29	2	12.4	0.8	
383	S—802	20	20	1	—	20	—	43	2	49	—	117	3	225	24	1	10.0	0.4	
384	S—804	—	—	—	—	—	—	37	—	74	13	139	2	235	15	—	6.0	—	
385	S—834	4	—	5	—	10	—	61	—	75	18	145	—	232	12	6	7.2	2.4	{Very thick walls.
386	S—835	246	45	4	—	—	—	—	—	—	—	—	—	205	44	1	18.0	0.4	
387	S—895	—	—	—	—	—	—	35	1	204	6	11	0	243	7	—	2.8	—	

* Data based on 70 plants examined.
† Data based on 50 plants examined.

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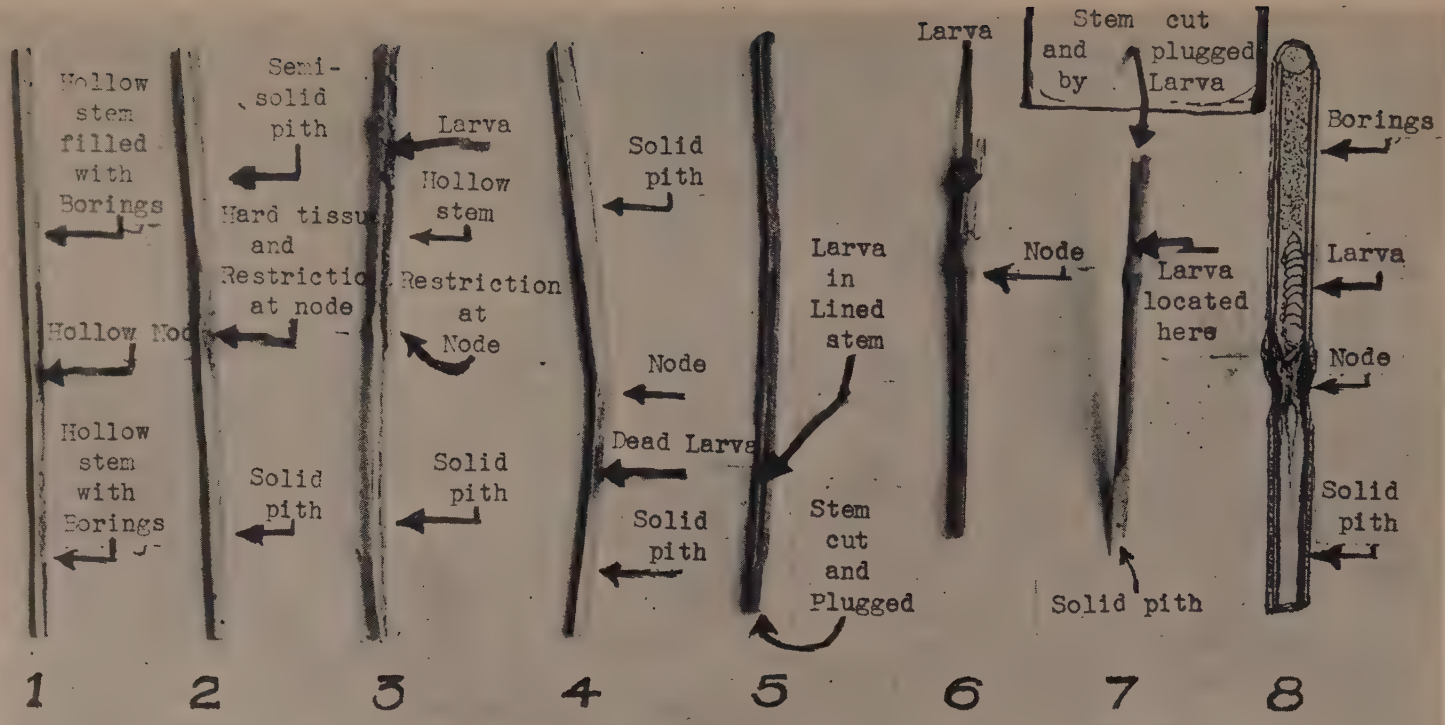
More recent observations in the examination of over 10,000 culms from 38 solid stem varieties, show that the larvae seldom succeeded in boring through the node. The wall of the culm at the nodes of the solid stem varieties was found to be thicker than those of hollow stem varieties such as Marquis. Also, the inside diameter of the culm at this point was considerably reduced and the pith adjoining somewhat denser, thus providing considerable obstruction to the downward or upward travel of the larvae. The movement of the larvae, therefore, was confined mainly to one internode and usually only portions of the solid internodes were affected. Further, only a few of the infested stems were cut by sawfly. When examining stems in the laboratory, it was frequently found that the living larvae were lodged above the first, second or even third node. The larvae had apparently found it impossible to pass the node and reach the base of the stem, their normal over-wintering position. Portions of these solid stems showing the larvae just above the nodes are to be seen in the accompanying plate, Figure 1. Stem No. 1 is an infested hollow stem of Marquis wheat. The node appears hollow as well as the internodes. Although the aperture at the node is slightly reduced, the movements of the larvae were apparently not hindered. Stem No. 2 is semi-solid or almost completely filled with pith above the node. The lower internode is solid or completely filled with pith with the exception of a small cavity just below the node. The distance between the inner walls of the culm becomes much smaller at and through the node. The cell tissue at this point is also hard. The restricted passage, together with the hardened cell tissue, appeared to be quite effective in resisting the efforts of the larvae to bore through. Stem No. 3 shows the larva, which was found alive in December at the time of examination of the stem. Borings show that it had travelled as far as the node where apparently it could make no further progress. In stem No. 4 an egg was laid and hatched in a small cavity below the node of a solid stem. The larva developed partially and died. Stem No. 5 is semi-solid and was severed by the larva just above the node and plugged at the lower end, which is unusual. Stem No. 6 is cut away at the top to expose a larva which had lined the stem just above the node to establish its wintering quarters at that point. Stem No. 7 is similar to that of No. 6. The stem was cut and plugged by the larva three fourths inch above the centre of the node. The stem below the node is filled with solid pith. The larva is expected to be located between the plugged end and the node The sketch at No. 8 illustrates the apparent resistance offered to sawfly larvae movements by the decreased opening through the node, together with the accumulation of hard cell tissue at that point.

CONCLUSIONS

Observations and experiments at the Dominion Experimental Station, Swift Current, indicate that sawfly damage might be reduced to proportions of little consequence by the use of solid stem varieties of wheat. The solid stem varieties of wheat, however, should include kinds that are of good milling and baking value suitable for bread making purposes. Since varieties of *Triticum vulgare* with solid stems are available, the breeding of desirable solid stem high quality bread wheats is not an insurmountable obstacle.



RESTRICTION OF SAWFLY LARVAE MOVEMENT AT NODES OF SOLID STEM WHEAT

1. Infested Hollow Stem
2. Solid Stem Showing Node Restriction
3. Larva Arrested by Node Restriction
4. Dead Larva in Small Cavity below Node
5. Larva in Stem Severed above Node
6. Larva Trapped in Stem above Node
7. Larva Trapped above Node & below Plug
8. Sketch - Larva Movement Stopped at Node

FIGURE 1

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Résumé

Etudes des variétés de blé à tige solide au point de vue de la répression de la mouche à scie de la tige du blé. H. J. Kemp, Station expérimentale fédérale de Swift Current, Sask.

Les observations et les expériences qui ont été faites à la Station expérimentale fédérale de Swift Current indiquent que l'on pourrait réduire peut-être à un minimum de peu d'importance les dommages causés par la mouche à scie de la tige du blé si l'on se servait de variétés de blé à tige solide. Il faudrait cependant que ces variétés de blé à tige solide comprennent des espèces qui ont une bonne valeur meunière et boulangère, qui sont bonnes pour la fabrication du pain. Comme il existe des variétés de *Triticum vulgare* à tige solide, la production de blé à pain à tige solide de haute qualité ne pourrait pas être un obstacle insurmontable.

UNDULANT FEVER AND THE DAIRY INDUSTRY

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The need for active and intimate co-operation between all fields of science and between science, producers, and the purveyors of food is essential for the ultimate control of many of our most stubborn human diseases. Among the numerous examples of such effort is the combat against that long and universally feared disease—tuberculosis. Efforts to control this "white plague" would be of little or no avail were it not for the complete co-operation of the milk producer with the veterinarian, the veterinarian with the bacteriologist, the bacteriologist with the hygienist, the hygienist with the medical doctor and the municipal or political authorities. Robert Koch, the discoverer of the tubercle organism, considered at one time the organism of bovine origin to be incapable of initiating the disease in the human; little doubt of this fact now remains.

It took twenty-one years to observe that the organism isolated by Bernard Bang of Denmark and named *Bacillus abortus* was similar in its basic characteristics to the etiological factor Malta fever; and it has taken another sixteen years to demonstrate that the organism considered by Bang to be the etiological factor of infectious abortion in cattle is also pathogenic for man. Although, unlike the tubercle organism, *Brucella abortus* does not manifest a similar clinical picture in each host, there remains little doubt that it can initiate human disease.

In Canada and in the United States, the disease in humans caused by the abortus organism is known as "undulant fever." The mode of transmission of the organism from animal to human is again somewhat comparable to that of the tubercle organism, viz., by infected milk. Because of this, we are dealing with a problem which directly concerns both the consumer and the producer.

Infectious Abortion

Bang's organism, now known as *Brucella abortus*, was discovered in 1896. Since that time an immense amount of work has been carried on in an attempt to subdue or control infectious abortion in cattle. The attempts to cure or to immunize animals against the disease have been sadly unsuccessful, and the malady must still be classified as "incurable." That the disease in cattle is now world-wide is evidenced by reports from every country where cattle raising or dairying is practised.

The presence of *Brucella abortus* in the milk of cows was first foreshadowed in 1899 by Theobald Smith of the United States Bureau of Animal Industry; his observation has now been amply confirmed by both the guinea pig inoculation and the direct Petri-plate methods. Sufficiently serious is the dairyman's loss of valuable foundation stock and the resultant diminished milk supply; but still more serious, more far-reaching, is the medical aspect—the relation to undulant fever in the human.

To make the question still more perplexing, it has now been shown by experiment that *Brucella abortus* is transmissible to dairy products such

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as butter and ice cream, and is viable in these products for a period longer than the average holding time.

Malta and Undulant Fever

The general features of Malta fever (Mediterranean undulant fever), with its long-drawn pyrexia, characteristic recrudesence, associated splenic enlargement and low mortality, have been familiar for many years along the Mediterranean littoral. The history of the disease affords an excellent example of a bacterial disease, the control of which was not immediately affected by the discovery of its causative agent. While Surgeon David Bruce, a British Medical Officer, reported the discovery of the organism causing fatal cases in the soldiers stationed on the Island of Malta, in 1887, the mode of infection remained obscure until 1905, when Dr. Zammit found the organism in goats.

Since goats' milk was used by the British troops at Malta, it was immediately suspected of being the carrier of the disease germ to the human. Steps were taken by the British Army and Navy to stop the supply of goats' milk to the troops at Malta, and this resulted in the almost complete eradication of the disease on the island within one year. The disease in that locality became known as Malta fever. Bruce, considering the organism a coccus, named it *Micrococcus melitensis*. It is now known that the observation of the discoverer was incorrect and that the organism is rod-form. In honour of Bruce, this and related organisms are now classified under the genus *Brucella*—the organism found by Bruce as *Brucella melitensis*, that found by Bang as *Brucella abortus*, and another found by Traum, in hogs, as *Brucella suis*. It is now a well established fact that all three species of Brucella are pathogenic for human beings. Data in support of this fact have come from workers in North and South America, the British Isles, and many European countries.

Kennedy (*1*) in 1914 showed that agglutinins for *Brucella melitensis* were sometimes present in the milk and serum of cows in England, and was the first to suggest that undulant fever might be of bovine origin.

The interesting observation that the organism which had caused Malta fever in the British troops was identical with the much-studied organism responsible for infectious abortion in cattle was made by Alice Evans in the United States in 1918. The above observation immediately directed attention concerning the cause of cases of undulating fevers in North America in persons who had no direct or indirect contact with goats, but who lived on farms where infectious abortion of cattle was prevalent. Suspicions that the organism causing infectious abortion in cattle might be pathogenic to the human became fact when, in 1924, Dr. Keefer, of Johns Hopkins Hospital in the United States, reported the isolation of *Brucella abortus* from a case of undulating fever.

The disease caused by *Brucella abortus* is now termed undulant fever. The clinical course of undulant fever caused by *Brucella abortus* infection is, as a rule, milder than that of Mediterranean undulant fever. The patient develops a continued remittent fever, lasting for some weeks and falling by lysis, but sometimes followed by one or more relapses. The duration of the febrile period is very variable, lasting for a few weeks up to many months. The fever is accompanied by headache, loss of appetite,

weakness, a tired feeling, sweating and wasting. The pulse is relatively slow. The blood frequently shows a slight leucopaenia, with a relative lymphocytosis. The spleen, and often the superficial glands, may be enlarged, and joint and muscular pains are common. The clinical symptoms are in many ways comparable to those of rheumatic fever, and there is evidence to indicate that in this country Brucella infections are sometimes incorrectly diagnosed as rheumatic fever.

Undulant Fever in Canada

The first report of undulant fever in Canada was by Harris (*2*) in 1928. Since that time, cases have been reported sporadically from every province of the Dominion except Prince Edward Island. Hardman (*3*) reports that in Ontario alone 225 cases have been reported within a two-year period. The disease exists in Quebec, with an incidence of cases which is not yet determined. The Provincial Bureau of Health in co-operation with Macdonald College is now making a concentrated effort to gain more information on the prevalence of the infection and the modes of transmission of the causal organism. There is little doubt that human infections with *Brucella abortus* exist to a much greater extent than has previously been considered. Dible (*4*) points out that some 20% of cases of undulant fever fail to show agglutinins. If we summarise the epidemiological and experimental evidence, we see that undulant fever must now be clearly recognized as a widespread infection, which in a very large proportion of cases is evidently carried by the bovine species. In the United States it appears that swine are also important agents in the transmission of the etiological factor. Apart from the clear clinical cases of the disease, there is also abundant serological evidence of the occurrence of mild infections and subinfections. In some cases these infections appear to result in vaccination and immunization, a converse condition of affairs to that which holds for true Malta fever.

There is evidence to show that the pathogenicity of *Brucella abortus* for the human is increasing. It has been stated by Hall (*5*) that "undulant fever prevalence may be on the up curve, potentially at least. If nothing is done to control the disease a great endemic wave of this ailment among men, in the not too distant future, is a catastrophe which is well within the realm of the possible." In the opinion of the author, two factors are now influencing the reported increase of undulant fever in Canada: first, the recognition of the infection because of more complete clinical information concerning the disease; and, second, a steady increase of virulence of the organism. It is a well known fact that the pathogenicity of certain organisms increases and decreases to form definite cycles. It is possible that at the present time we are on the phase of increasing virulence of the *Brucella abortus* cycle. Just what degree of virulence the organism may reach must be left to presumption.

That *Brucella abortus* is concerned with the etiology of undulant fever in Canada has been revealed by the recent work of Thompson (*6*), who has succeeded in isolating the organism from two cases of undulant fever in the province of Quebec. So far as the author is aware, this represents the first isolation from a case of undulant fever in Canada of an organism exhibiting the peculiar carbon-dioxide requirements of *Brucella abortus*.

In one case the organism was also isolated from the milk supply used by the patient; the two organisms were compared, and little doubt remains regarding their identity. Gilles (*7*) has shown that in France cattle are frequently infected with the *melitensis* strain of Brucella and that, while a certain number of cases were infected through drinking milk from infected animals, the etiological agent did not exhibit the peculiar properties of *Brucella abortus*.

Based on the evidence that few goats are maintained in Canada, and that the organisms isolated from infected animals in Canada are always the *abortus* and not the *melitensis* strain, it is unlikely that the *melitensis* strain plays an important role in the etiology of undulant fever in this country.

Methods of Control

Unfortunately, there is at present no effective prophylactic treatment; the treatment is symptomatic. The mortality rates from undulant fever appear to be somewhat higher in Canada than in other countries. Hardman (*3*) reports a case fatality rate of 6.6%; Hardy (*8*) considers the mortality rate in United States to be about 3%; Dible (*4*), who has made an extensive survey of mortality rates of the disease, states that the mortality is low but definite, being about 2 to 3%. Owing, however, to the limited amount of definite data on this question, the above figures may be somewhat misleading. While the mortality rates may not be high, the disease, because of the excessive temperatures produced and the long disability period (sometimes six months), should be considered to be of paramount importance in public health administration.

Effect on the Dairy Industry

According to the foregoing information, the reader may well judge for himself the future course of the dairyman. That infectious abortion (Bang's disease) in dairy cattle is widespread in Canada is evidenced by reports from veterinarians and farmers from every province. Watson (*9*) based on data compiled from results of serological tests carried out two years ago, estimates about 20% infection. No statistics are available to show the relative infection in the various provinces. Dr. R. L. Conklin, technical adviser to the Veterinary Service for the Province of Quebec, presents figures to indicate 12% infection in the province. It has been shown by Gwatkin (*10*), and also by Thompson (*11*), that *Brucella abortus* is eliminated with the milk of a high percentage of cattle reacting to the blood test in dilutions of 1 : 100 or higher. Pasteurization will render milk safe from the viewpoint of undulant fever; this method of protection appears very simple, and rightly so, for well organized towns and cities in so far as direct milk consumption is concerned, but is quite impractical for rural communities.

The transmissibility of *Brucella abortus* from milk to dairy products is an important problem from the dairyman's viewpoint. It is neither convenient nor practical to pasteurize milk for the production of cheese; few farms, indeed, are equipped to effectively pasteurize the cream used in the home manufacture of butter or of ice cream. The question of "certified" and "special" milks are causing much concern to public health

authorities. These milks are *not* pasteurized. Few herds producing certified milk are at the present time free from infection with *Brucella abortus*. The organism has been isolated from certified milk in Montreal. Are public health authorities entirely justified in allowing the consumer to believe that, because he pays a higher price for certified milk, he is receiving a product which is safe for his family?

Attempts are already being made to eradicate the disease in cattle. Because of the widespread nature and the frequency of the disease in Canada, the reader may easily visualize the difficulties confronting such an undertaking. Any system of wholesale slaughter seems prohibitive at the present time. It has been shown that although cattle may show no clinical symptoms of infection, they may be "carriers" and may eliminate the organism with the milk. The province of Ontario is making an effort to eradicate *Brucella* infection in prescribed areas and seems to be meeting with encouraging results. This action will result in a two-fold benefit to the farmer; it will not only insure that his milk supply is safe for human consumption, but also will enable him more advantageously to dispose of his surplus stock.

The first step in the successful control of an infectious disease is to understand the disease biologically. The most important biological fact in connection with an infectious disease is its causative agent. While our knowledge of the microbial cause of undulant fever has developed significantly during the past few years it is certainly not complete: suffice it to say that recent findings of workers in Canada, United States, Great Britain and European countries incriminate *Brucella abortus* as the cause of an appreciable number of cases of undulant fever. We are just beginning to realize the importance of the disease in Canada. It is an established fact that we have in our country a great many dairy cattle infected with *Brucella abortus* and that the organism is frequently eliminated with the milk. It has been pointed out that statistics do not show a high co-relation between the consumption of raw milk and the incidence of undulant fever, but on the other hand, people who contract undulant fever are usually drinkers of raw milk. There are several logical reasons to explain the present low incidence of the disease. It must be borne in mind that the incidence is on the up-curve. The most satisfactory method of control lies in prevention. The co-operation of the producer, the veterinarian, the physician, and the public health authorities is needed to combat undulant fever successfully.

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Résumé

La fièvre ondulante et l'industrie laitière. R. Thompson, Collège Macdonald, P.Q.

Il ressort de certaines enquêtes qui ont été conduites tout récemment au Canada sur l'existence de la fièvre ondulante et de l'avortement infectieux (maladie de Bang), que ces maladies se rencontrent dans notre pays en proportion beaucoup plus grande que l'on ne s'imagine généralement. Les cas de fièvre ondulante chez l'homme augmentent sans cesse et près de vingt pour cent des troupeaux laitiers sont affectés d'avortement épizootique. Le *Brucella abortus*, l'agent étiologique de cette maladie, chez l'homme aussi bien que chez les animaux domestiques, peut se transmettre au beurre et à la crème glacée. Il semble que la virulence de cet organisme augmente.

Les tentatives que l'on a faites en ces trente dernières années pour extirper l'avortement infectieux des troupeaux de bovins ont complètement échoué. On ne connaît pas encore de traitement satisfaisant pour la fièvre ondulante. Il est donc tout à fait évident que nous devons chercher les moyens de prévenir l'infection plutôt que de chercher à guérir la maladie après qu'elle s'est établie. Ce n'est que par l'union complète des efforts entre le laitier, le médecin et le consommateur que nous pouvons espérer combattre les ravages de l'infection du Brucella dans notre pays.

CANADIAN ACCESSION SYSTEM FOR CEREAL CROPS

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Until 1933 cereal workers and plant breeders in Canada had no system of accessioning varieties outside of the particular institutional systems. This state of affairs was not only confusing but far from satisfactory, particularly when articles were published or the performance data on a group of varieties were compared. If by chance the varieties possessed the United States Bureau of Plant Industry C.I. numbers some help was given, but in many cases varieties in Canada do not possess this means of identification and consequently an element of uncertainty was introduced when varieties could not be clearly traced to their origin. Further confusion was caused when these varieties became available to the general grower.

At the Plant Breeders meeting of the Canadian Seed Growers' Association, held in Winnipeg in 1929, the question of the need of a wholly Canadian system of accessioning was introduced for discussion and possible action. The general opinion was strongly in favour of a suitable system, and a small committee composed of Dr. L. E. Kirk and J. G. C. Fraser was instructed to bring in a report and recommendations at the next meeting of the Plant Breeders Committee.

After corresponding with the various institutions using accession systems, both in America and abroad, and after a careful study of these systems, the committee recommended a comparatively simple system based partly on the United States Department of Agriculture Bureau of Plant Industry system and partly on the best points taken from the other systems investigated.

The report was accepted and the Cereal Division, Central Experimental Farm at Ottawa, was given the task of getting the work under way. All agricultural institutions, both Provincial and Federal, were circularized and asked to co-operate by sending in a list of the cereal crop varieties they wished to have listed in the new system, which has been designated "The Canadian Accessioning Number System".

Due to delays of one kind or another, the listing of the varieties was not completed until July, 1933, when a progress report was presented at the Plant Breeders meeting held in Regina. In January, 1934, mimeograph copies of the lists of all the varieties of wheats, oats, barleys, flax and beans were completed and mailed to those co-operating. The work will continue and, periodically, supplementary lists will be published.

It is interesting to note that, in the August issue of this magazine, Dr. O. S. Aamodt, of the Univeristy of Alberta, in his article entitled "Resistance of wild oats and some common cereal varieties to freezing temperatures" has made use of the new accessioning system. This is the first published article in which the Canadian Accessioning Numbers (C.A.N.) have been used and it is suggested that Canadian agronomy workers should make use of this accessioning system as far as possible, in order that references to seed stocks of varieties grown in Canada may be readily traced.

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A MALADY OF THE POTATO IN ALBERTA SIMILAR TO PSYLLID YELLOWS[1]

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There is in Alberta a malady of the potato which appears to resemble closely psyllid yellows, recently described by Richards and Blood (*1*), and said by them to be destructive in Utah, U.S.A., and present in certain neighbouring states. They found the malady to be associated with the feeding on the vines of nymphs (only) of *Paratrioza cockerelli* Sulc. As to its seriousness, they state: "Psyllid yellows, in its effect upon the plant, must be ranked among the most destructive of known potato diseases." When the plant is attacked during early stages of tuber formation, no crop results, and early death of the plant frequently ensues. They also state: "The symptomology of psyllid yellows varies greatly with the number of insects feeding, the length of feeding period, and the intensity and duration of light exposure during the time of feeding", and further: "Psyllid yellows is systemic and affects the form and physiology of the entire plant".

Each year from 1919 to 1922, inclusive, in 1924, and from 1927 to 1933, certain potato plants here and there in central Alberta have developed rather consistent symptoms, which suggest a type of disease different from others known here. Affected plants develop naturally for a time, then become more or less abnormal. Most common is a slight to definite swelling of the nodes, lengthening of the internodes in some plants, and a shortening of them in others, deformed axilliary branching, with aerial tubers in certain severe cases, and, as a rule, few to no tubers develop. Usually plants are more or less stunted or rangy in appearance, and the leaves more or less rolled. Frequently affected plants resemble severe cases of the disease caused by *Rhizoctonia Solani*. These have extensive axilliary branching and aerial tubers, and the roots and stem-parts below the ground are without lesions of any kind. The photograph of one of these plants, which appears in Figure 1, A, is not unlike a type shown by Richards and Blood in their text Figures 3, B, and 4, D (left). While such cases are not uncommon, the type most frequently found is that without pronounced axilliary branching or aerial tubers (Figure 1). With the exception of the Medicine Hat case, presently referred to, affected plants so far observed do not occur in close proximity, but here and there in the field.

The Medicine Hat case just mentioned was an outstanding exception, in point of severity and in its epidemic nature, to what has been described, but not essentially different in gross symptoms. Affected plants, fresh from fields of central Alberta, were compared with those from Medicine Hat in southern Alberta, and the symptoms on many plants appeared to be identical. Many plants of the Early Ohio variety from Medicine Hat exhibited the odd, bushy, and tuft-like second growth from the stalks identical with the photograph of plants shown by Richards and Blood in

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A. Vines of Cobbler variety with pronounced deformity, shortened internodes, and no tubers. B. Vines with symptoms intermediate to "A". C. Tuft-like second growth and rolling of leaves of affected Early Ohio vines from the Medicine Hat case (see text).

Figure 5, C, of their paper, and reproduced here, by their courtesy, in Figure 1, C. They stated that this type of growth is a characteristic peculiar to Early Ohio affected with psyllid yellows.

Over 100 acres in a local area in and about Medicine Hat in 1932 were a total failure. Early Ohio and Bliss Triumph failed to recover, and even small tubers were extremely scarce. Certain late varieties made some recovery late in the season. Tomato plants nearby were affected similarly. The malady was not observed in the same area in 1933.

In order to ascertain whether progeny from affected potato plants would transmit the symptoms, tubers from 20 plants of the Medicine Hat case (including all varieties affected), and from 40 plants obtained near Edmonton, in north central Alberta, were planted at Edmonton in 1933. The progeny and plant from each tuber were apparently normal in every respect. Richards and Blood found that tubers from affected plants did not appear to transmit the disease.

The Medicine Hat case was not reported until late in the season, but the general nature of attack at that time strongly suggested insects had been involved. Mr. E. H. Strickland, Professor of Entomology, University of Alberta, kindly informed me that, in 1928, tomato plants grown in a greenhouse at Medicine Hat were severely infested with a psyllid which resembled *P. cockerelli*, but which could not be determined with certainty. He also states: "A few psyllid nymphs have been found on the leaves of potatoes which were growing in this district. Four species of this family are known to occur in Alberta, but *P. cockerelli* has not been definitely recorded from the province."

Whether all these symptoms described herein were caused by *P. cockerelli*, or by other insects, or agents, has not been determined. However, there appear to be many points of close similarity with the psyllid yellows described by Richards and Blood.

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THE ECONOMIC ANNALIST

A REVIEW OF AGRICULTURAL BUSINESS PREPARED QUARTERLY BY THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA

Vol. IV, No. 3. September, 1934

THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

The index number of wholesale prices in Canada was fractionally lower in July as compared with June moving downward from 72.1 to 72.0. Vegetable products moved up from 67.4 in June to 68.5 in July. Non-metallic minerals advanced from 85.6 to 86.1 while other sub-indexes were lower, the index of animals and their products falling from 66.6 to 65.6. The general index was however 1.5 points above that for July, 1933. While data for the latest month are not available, wholesale prices in United States have been tending upward. The index for July, 1933 (Bureau of Labor Statistics) was 68.9 whereas in June, 1934, it was 74.6, the highest point reached in that period. In the United Kingdom the Board of Trade index for June, 1933, was 101.7 as compared with 103.6 in July of this year. There has been a slight tendency for this index to recede. The June index was however well above that for May. In France, wholesale prices have been falling steadily since last December. The index in June of this year was 363 as compared with 396 in the same month in 1933. During the same period wholesale prices in Germany have tended to rise. In Italy they have been moving downward slowly. Monetary policies would of course have to be taken into consideration. These indexes are given however to indicate the course of prices within the respective countries. The general tendency recently has been toward lower levels.

Retail Prices —The Bureau of Statistics index number of retail prices, rents and costs of services rose from 78.2 in May to 78.4 in June, due apparently to advances in the prices of food, in which group the index rose from 67.6 to 68.4. Considering retail prices in several of the more important countries, it is interesting to note that in 1933 the Bureau of Labor Statistics index of prices of foods in the United States was 71.7 in July, 1933, whereas in July, 1934, it was 75.2. The tendency has definitely been upward. Indexes for corresponding dates in the United Kingdom were 118 and 122. In France in July, 1933, the wholesale index was 79.8, whereas in June, 1934, it was 77.5. The tendency has been downward since the first of the year. In Germany, the index of food prices has followed a slightly irregular course rising until December, 1933, and falling to 113.3 in May, 1934. There was however a sharp advance to 115.5 in June.

Physical Volume Business.—Indexes of production for the month of July have been added since this was written, however, taking the trend in the last 12 months into consideration, it will be observed that there has been a substantial increase in business activity. The index for June, 1934, was 95.8 against 82.2 in June, 1933. Similiarly industrial production was 95.2 as compared with 79.8 Mineral production has with the exception of July, 1933, been well above the monthly average for 1926. Manufacturing has been at a higher level as well but perhaps not quite as active as

AN ECONOMIC ANALYSIS OF CREAMERY OPERATIONS IN NEW BRUNSWICK

C. V. PARKER[1] and J. F. BOOTH[2]

The purpose of this article is to present a synopsis of the results obtained in a study of the business operations of eleven New Brunswick creameries.[3] The data contained in this article were collected in 1933 and apply to the 1932 operations of the creameries.

The production of creamery butter in New Brunswick has increased materially in recent years while the output of cheese has declined. Relatively better prices for butter and increased production of live stock requiring the use of skim milk are responsible in the main for the diversion of milk from cheese factories to creameries. The output of creamery butter in 1932 reached 2,759,519 pounds compared with 1,416,355 pounds in 1926. The production of dairy butter in 1932 was 7,456,000 pounds which, when added to creamery output, made a total of 10,215,519. Domestic consumption of butter, however, is still in excess of supply; there is therefore an opportunity for expansion of the dairy industry. The extent of the expansion will depend largely upon the degree to which dairy farmers increase their home-grown feeds or can buy mill feeds at a sufficiently low price to ensure satisfactory profits on sales of butterfat.

From the creamery operator's point of view the chief difficulty in factory operation is in obtaining sufficient quantities of cream for economical operation. There are at present 21 creameries doing business in the province and many of these creameries have a comparatively small output. This difficulty arises from the fact that the agricultural areas are scattered, small and sparsely settled. Patrons in many instances live a considerable distance from the creameries, and in the majority of cases the patron's business is relatively small.

The Provincial Government for the past few years has been aiding creamery operators and patrons alike by contributing to the expenses of cream transportation. This has had the effect of placing on an equal footing all farmers who are within reach of an established creamery. The additional cream received from outlying districts helps to reduce the per unit cost of operations and, without the subsidy from the Government, many of the smaller plants would be forced to cease making butter.

The present study was undertaken for the purpose of obtaining information on the costs of operation in relation to volume of butter production and costs of transporting cream Data on other factors such as financial and operating statements, prices received and so forth were also obtained and taken into account.

The eleven creameries studied made 1,997,516 pounds of butter in the 1932 operating season. Butter output per creamery ranged from 13,448 pounds to 903,600 while the average make was 181,592 pounds. The number of patrons averaged 392 per creamery and varied from 50 to 1,260.

Cost of Manufacture.—The following cost figures do not include the charges for transporting cream to the factory or freight on butter from the factory. Items making up total cost were taken from factory statements with the exception of interest and depreciation charges. Interest was charged on the present value of buildings and equipment at the rate of 5%. On buildings a 2% rate of depreciation was charged for brick and 5% for frame structures. Depreciation of equipment was calculated on the year's future use basis; present values and year's future use were obtained for each of the important items, and by dividing the number of years into the present value, a depreciation figure for the year in which the study was made was obtained.

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[3] In conducting the study the New Brunswick Department of Agriculture co-operated with the Dairy and Economics Branches of the Dominion Department of Agriculture.

TABLE 1.—COST OF MANUFACTURING A POUND OF BUTTER IN 11 NEW BRUNSWICK CREAMERIES, 1932

Creamery	Pounds butter made	Manufacturing expense	Cost per pound butter
		$	cts.
A	49,602	2,877.49	5.80
B	114,275	5,607.41	4.91
C	124,975	5,522.58	4.42
D	224,405	22,311.95	9.94
E	320,062	16,012.30	5.00
F	29,296	3,406.54	11.63
G	62,208	2,369.26	3.81
H	13,448	1,340.23	9.97
I	95,576	2,927.17	3.03
J	903,600	25,891.63	2.86
K	59,069	2,231.15	3.78
Total or average	1,997,516	90,497.71	4.53

The cost of manufacturing a pound of butter for each of the creameries is presented in Table 1. The average cost per pound of butter was found to be 4.53 cents. This figure varied from 2.86 cents to 11.63 cents between individual creameries. While the largest creamery had the lowest unit cost and the two smallest plants had the highest costs the number of factories included in the study was not sufficient to overcome the effect of unusually efficient or inefficient creameries; therefore it was difficult to establish a relationship between volume and costs such as is ordinarily found in cases of this kind and as would undoubtedly be found in this instance if data had been available from a much larger number of factories.

In Table 2, the items of cost are segregated under the headings of Labour, Materials and Miscellaneous, and Overhead. Here we find that labour costs amount to 0.85 cent per pound in factory "J," which had the largest output, while for "H," the smallest plant, the cost is 5.30 cents per pound of butter. Labour charges for factory "D" seem to be considerably out of line with those of other large creameries.

Materials and miscellaneous items comprise approximately 33% of the total charges. Under this heading are included manufacturing and office supplies, fuel, ice, light and power, repairs and other items. The amount spent per creamery ranged from $265 to $12,474 for items in this category. On the average the cost of these items per pound of butter was 1.64 cents. Except for creameries "D" and "F" the charges per creamery for these items did not vary greatly from the average. No great difference should occur because the quantity and price of materials used per unit of product manufactured is approximately the same regardless of output.

The items included under overhead were taxes, insurance, interest and depreciation. These formed slightly over 27% of the total manufacturing costs. The average cost of these items per pound of butter was 1.24 cents. This figure varied from 0.54 cent to 3.56 cents for individual creameries, and tended to decrease as production increased.

Cream Transportation Costs.—Approximately two-thirds of the patrons associated with the eleven creameries had their cream hauled to the creamery by the truck-route method. There were 50 routes in operation in 1932. The number of miles travelled by trucks per route was high, averaging 100 miles per return trip and ranging from 15 to 252 miles for individual routes. The cost of operating a route for the season ranged from $21 to $2,037 and averaged $543 per route. The cost per pound butterfat varied from 0.79 cent to 4.78 cents and averaged 2.46 cents on all routes. Distance travelled per route and pounds of butterfat hauled per trip were the main factors influencing the cost of getting the cream to the factory.

TABLE 2.—LABOUR, OPERATING AND OVERHEAD COSTS IN 11 NEW BRUNSWICK CREAMERIES, 1932

Creamery	Pounds butter made	Labour	Materials and miscellaneous	Overhead	Total making costs
		Cents per pound butter			
A	49,602	2.50	1.55	1.76	5.80
B	114,275	2.24	1.48	1.18	4.91
C	124,975	0.90	1.86	1.65	4.42
D	224,405	4.00	2.93	3.01	9.94
E	320,062	2.03	1.56	1.41	5.00
F	29,296	4.49	3.58	3.56	11.63
G	62,208	1.12	1.28	1.41	3.81
H	13,448	5.30	1.97	2.69	9.97
I	95,576	1.34	1.15	0.54	3.03
J	903,600	0.85	1.38	0.64	2.86
K	59,069	1.61	1.24	0.93	3.78
Total or average	1,997,516	1.65	1.64	1.24	4.53

One problem which has a tendency to increase cream transport costs is the overlapping of cream routes. In many places the trucks from two creameries cover almost the same territory while at several places trucks run on the same road as a result of competition for business. It is evident, however, that the patron is paying for this duplication of services and it would be greatly to his advantage if through organization some means could be devised to map out routes in a more efficient manner.

Prices Received.—The average price received for butter by the eleven creameries was 20.2 cents per pound in 1932. On a butterfat basis this figure was 24.4 cents. On the other hand patrons were paid 18.9 cents per pound for butterfat so that creamery men were working on a margin of 5.5 cents. Manufacturing expenses, transport costs on cream routes and freight on butter amounted to slightly over 7 cents per pound butterfat; therefore, the creameries as a whole were operating at a loss in so far as the manufacture of butter was concerned. Interest and depreciation charges were included as an expense.

Business Analysis.—An analysis of the balance sheets and operating statement of the 11 companies takes into account the total business conducted by these firms. Many of the factories make ice cream and some sell milk and cream.

The analysis of the balance sheets for the eleven companies indicated that the majority were in a fairly sound financial condition. While some creameries were carrying a greater amount of current liabilities than could be met by current assets, the current ratio for the eleven concerns as a whole was 1.17 to 1, indicating that the majority were favourably situated in this respect. A less favourable condition is indicated by the proportion of net worth to debt, which was 0.63 to 1 for all companies. This was due wholly to the unsound position of three of the companies. Only two companies carried a reserve for contingencies, but eight of the eleven had a surplus of assets over liabilities.

The analysis of the operating statement, however, indicated that the majority of companies operated at a loss in 1932. Seven of the eleven had a debit balance for net operating income. Six of the companies paid dividends but it is suggested that some of these did so at the expense of drawing on funds which should have been carried into reserve for depreciation purposes. In constructing the operating statements, depreciation charges were adjusted upwards in some cases where sufficient amounts were not being charged to the business. This explains why some companies paid dividends when they apparently had deficits.

EFFORTS TO CONTROL MARKETING BY GOVERNMENT BOARDS OR ORGANIZATIONS ACTING WITH GOVERNMENT SUPPORT

PART III [1]

J. COKE [2]

New Zealand has exercised control of the marketing of farm products for more than a decade. The Meat Export Control Act was passed in 1921 and was followed by the Dairy Produce Control Act in 1923, the Fruit and Honey Control Acts of 1924, and the Kauri Gum Export Control Act of 1925. The Wheat Purchase Board was authorized by Order in Council in 1933. There is a certain similarity in the functions of these boards although the wheat plan includes both domestic and export sales.

The Dairy Produce Control Board consists of 12 members, 9 of which represent dairy farmers, 2 represent the Government, and 1 represents manufacturers of dairy produce. Its finances are provided by a levy of 1/8d. per pound on all butter exported and 1/16d. per pound on all cheese exported. This board has power to exercise either limited or absolute control over marketing of dairy produce. For the greater part of the time, however, it has exercised limited control, that is, it has confined itself to licensing exporters; controlling and improving quality; arranging shipping, insurance, and storage contracts; auditing accounts; supplying market information; and advertising dairy produce under a national brand.

In 1926 intention to exercise absolute control was declared. The board then undertook to regulate distribution and to fix prices to the trade in Great Britain. This aroused opposition both in overseas trade and at home. Large stocks were accumulated in storage which had to be liquidated eventually at unsatisfactory prices. This policy was abandoned in 1927. There is still some support for such a policy in New Zealand because some felt that, had the board held out somewhat longer, better results would have accrued. The desirability of such a policy and other matters related to the overseas market for dairy products are now under investigation by a Royal Commission. A measure of co-operation has been effected with the Australian Dairy Produce Control Board.

The Fruit Export Control Board operates on a slightly 'different basis. A province may vote in favour of having its fruit marketed under control and if 70 per cent of those producing a stated minimum quantity for export are in favour, the fruit shall come under the Control Act. After a period of three years a vote may be taken and should a similar percentage be opposed, the products of the area will not be subject to control. Octago refused to export under the control regulations but in 1933 agreed to do so. The policy of the Board now is to sell through one wholesale firm in Great Britain.

The British Marketing Acts.

An entirely different set-up for marketing is found in the type of co-operation which was provided for under the British Marketing Acts of 1931 and 1933. It should be said that this form of organization was, insofar as I am aware, developed in Queensland, Australia, and took its first form in Wheat Pool Act of 1920 which, in turn, was followed by the Primary Products Act of 1922. The essential feature is that where the majority of producers of a commodity desire to sell the product collectively the minority may be compelled by law to join in such sales policy.

The British Agricultural Marketing Act of 1931 provides for the submission of schemes for the regulation of the marketing of agricultural products to the Minister of Agriculture who will then publish notice of the receipt of the scheme and a period

[1] See The Economic Annalist, Vol. III, Nos. 7, 8, 9, pp. 76-78, and Nos. 10, 11, 12, pp. 92-95.

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of six weeks will be set aside in which all objections must be filed with the Minister. If, on enquiry, the Minister is satisfied that the scheme will be advantageous to the producers of the commodity he may then submit it to parliament for approval. The Minister has power to modify the proposals but these modifications must be acceptable to the proponents of the scheme.

Each scheme is to be administered by a board. Every scheme requires a poll of registered producers affected. Not less than two-thirds of the producers, both in numbers and in volume of production, must vote in favor before the scheme can be adopted. A board constituted under the Act is given wide powers to engage in buying or selling, grading, packing, adapting for sale, and advertising farm products. Consumers committees may be set up to judge of the effects of any scheme on consumers. Two funds are established under the Act—a "Scotch fund" of £125,000 sterling and an "English fund" of £500,000. These funds may be loaned to any board administering a scheme. Both long-term and short-term loans are provided for. Renewals of loans are placed in the hands of agricultural marketing facilities committees. Renewals will not be granted on loans on which the interest has not been paid in full, in fact all renewals are carefully scrutinized.

The Act further provides for Agricultural Marketing Re-organization committees which shall be responsible for the preparation of schemes and review the operations of existing schemes and make recommendations to the Minister. Schemes for marketing hops, milk, pigs, bacon, and potatoes are already in operation and others for beet sugar, poultry, and fat stock are in various stages of development.

The Agricultural Marketing Act of 1933 provides, among other things, that where a board is administering two or more agricultural marketing schemes, one of which relates to a secondary product and one to a primary agricultural product from which the secondary product is wholly or partly manufactured (for example, pigs and bacon) it may submit schemes for the organization of the secondary industry which, under the Act, shall be known as a development scheme and which shall be administered by a development board. A development scheme for the organization of the secondary industry may require that no one shall produce the secondary product unless exempt or in receipt of a licence from the Board within the areas covered by the scheme. The Board may take over premises for the development of the secondary industry and dispose of them as it sees fit. Provision is made for the hearing of protests against such an action. The development boards are also empowered to make a levy on all marketing boards concerned in a development scheme.

This Act also empowers the Board of Trade to regulate imports and provides for setting up a Market Supplies Committee to review the conditions affecting supplies of agricultural produce in the United Kingdom and to advise the Secretaries of State for Scotland and Northern Ireland and the Ministry of Agriculture and Fisheries in regard to desirable policies.

Another amendment to the Act of 1931 is the provision whereby a board may regulate the amounts of a regulated product which any producer may sell. All producers must supply information deemed necessary for the purposes of the board. The Board of Trade is also empowered to obtain information as to stocks of agricultural products on hand.

This legislation has been criticized but obviously has the support of a large number. The Minister of Agriculture, speaking at Newton Abbott on March 10, 1933, said:—

"What the Marketing Bill says in a nutshell is this—we must organize the home market and the supplies to that market. If and when, however, the industry undertakes so to organize it must be guaranteed that it shall not be swamped out by an unorganized flood of produce landed on our shores in a succession of bankrupt sales. Furthermore, it says that the producer is not merely interested in growing his product but in what is done with it thereafter and that he and the manufacturer can full well come together to organize the secondary products . . . . ."[3]

Public Utility Control.

Public Utility Control has, until recently, been limited to such services as gas, electric light, water, communications and transport. Since 1932, however, milk prices in Winnipeg have been established by the Public Utilities Commission. The situation was brought about by the failure of representatives of dairy farmers and distributers to agree on prices and was aggravated by competition from chain stores and farmer distributers. The Board was reluctant to undertake this control and, in fact, at first refused to recognize it as coming within its jurisdiction. It was claimed, however, that the milk supply of Winnipeg was endangered and that the producers of fluid milk had equipped their farms for this especial purpose and had no other market; thus it was claimed that milk should be considered to be a public utility and that an emergency did exist.

As already mentioned chain store competition aggravated the situation. The question of chain store efficiency, policy and service relative to that of the regular distributer might have been a matter for consideration. This, however, was considered to be of less importance than the question of effecting a compromise with respect to prices. The prices of class A milk were established at $1.54 to the producer and retail milk, 10 cents per quart, relief milk off the wagon, 8 cents, milk sold to stores, 7½ cents, and bulk milk, 6¼ cents.[4] Prior to the establishment of these prices milk was selling at five to eight cents per quart and the producer was receiving less than $1 per hundred pounds.[5] Those critical of public utility control of milk prices claim that there is too much rigidity in the determination of prices and that the preponderance of consumers' interest may adversely affect prices from the farmers' point of view. Nevertheless this plan has spread to cities in Alberta and Saskatchewan.

Another method of establishing prices of milk is found in the setting up of special control boards for that purpose. Thus, in the State of New York, a Milk Control Board has been established for a period of two years with a view to "fixing the minimum price to be paid by milk dealers to producers and others, the maximum price to be paid by the consumer for milk used in fluid consumption, wheresoever produced." The minimum price to producers will, of course, apply to a locality. The Act also provides for price variation according to grades. Similar legislation has been passed in Pennsylvania and Ohio, and in Quebec and Ontario.

The Agricultural Adjustment Act.

The Agricultural Adjustment Act has been in force in United States since early in May, 1933. It does not embody entirely new plans for it is claimed that it has been developed during post war years and is a result of several efforts "to improve the farm situation by legislative and non-legislative measures . . . ."[6] "Previous acts have failed because of inability to cope with the fundamental difficulties of controlling excessive supplies, removing inefficient marketing methods and improving general purchasing power. The Agricultural Adjustment Act goes directly to two of these basic difficulties—unbalanced production and expensive marketing."[7] The former is to be met through the allotment plan and benefit or rental payments, and the latter, through provision for marketing agreements between farmers and the handlers of their products which must be approved by the Secretary of Agriculture before becoming effective.

This Act declares it to be the policy of Congress "to establish and maintain such balance between production and consumption of agricultural commodities and such marketing conditions therefor as will re-establish prices to farmers at a level that will

[3] Hon. Walter Elliot, "Agricultural Policy," Journal of the Ministry of Agriculture and Fisheries, Vol. XL, No. 1 (April, 1933), p. 18.

[4] Minutes of Proceedings and Evidence of Select Standing Committee on Agriculture and Colonization of the House of Commons (Canada), 1933 (Ottawa: King's Printer, 1933), p. 637.

[5] H. C. Grant, Some Notes on Public Utility Control of Milk in Manitoba, Canada (published in mimeograph form by the Department of Rural Economics and Sociology, University of Manitoba, Winnipeg), p. 4

[6] Ezekiel, M. and Bean, L. H. The Economic Bases for the Agricultural Adjustment Act, pp. 1 (7), Ibid. pp. 58.

[6] Ezekiel, M. and Bean, L. H. The Economic Bases for the Agricultural Adjustment Act, pp. 1.

[7] Ibid. pp. 58.

give agricultural products a purchasing power equivalent to that in the period August, 1909–July, 1914. In the case of tobacco the base period shall be the post war period, August, 1919–July, 1929." It was apparently recognized that such a policy would require some time in which to become effective. The interests of the consumers were protected by stating definitely the level of purchasing power to be attained and providing for readjusting farm production. It is worth noting that Title II of the Act provides for refinancing the Agricultural industry.

For the purposes of this article we need consider only the marketing agreements. These may in a large measure be regarded as the counterpart of the schemes set up under the British Marketing Acts but less comprehensive in scope. They apply to specified areas and products. Many of them set minimum prices to producers and limit wholesale and retail prices. Business is allotted between existing units and trade practices are prescribed as are the records to be kept and reports which shall be forwarded to the Secretary of Agriculture. Licences may be issued to dealers. It is hoped that high cost or inefficient marketing agencies may be eliminated. Thus we read: "Agencies entering into agreements with the Secretary of Agriculture may undertake to retire high cost inefficient services and to encourage the expansion of low cost services in the interest of greater volume of distribution relatively lower costs to consumers and a larger share of the consumers' dollar for the farmer." [8]

Regulation of supplies will mean, so it is claimed, better prices to the farmer. Under conditions of control of total supplies and known demand, "price-fixing is feasible" since important elements which determine prices are brought under control. It is recognized that control is limited to supply and to efficiency in marketing since demand is not to be affected except through diversions for relief purposes and by judicious advertising.

In the agreements submitted soon after the Act came into force there was distinct evidence of rigidity but some degree of flexibility is apparent in more recent submissions. This is particularly true in regard to the clauses relating to prices.

Conclusion.

The legislation referred to in these articles is evidence of the growing importance of the State in controlling business. The demand for such control arises in part out of the chaotic conditions of depression, and also is an expression of the necessity of adapting business to meet the requirements of society. We are still groping about for an effective means of increasing business efficiency. In so doing we must be careful to preserve the good points of business organization as we have known it and to add to it such social control as is necessary to protect the interests of the primary producers and those of marketing agencies which are capable of efficiently rendering the services required by consumers.

Dr. H. Barton, Deputy Minister of Agriculture, Dr. J. F. Booth, Economics Branch, Department of Agriculture, Dr. A. K. Eaton, Department of Finance, C. B. Davidson, Dominion Bureau of Statistics, and A. Gosselin, Economics Branch, Department of Agriculture, have been appointed to the Dominion Marketing Board authorized under the Natural Products Marketing Act, 1934. Dr. Barton will act as Chairman. The offices of the Board will, it is understood, be in the Confederation Building, Ottawa.

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[8] Ibid. pp. 64.

FARM CREDIT LEGISLATION IN CANADA, 1934.

Among the more important legislation passed at the fifth session of the 17th Parliament of Canada which prorogued July 3rd, were two bills dealing with Agricultural Credit. There were, Bill 92, "an Act to facilitate Compromises and Arrangements between Farmers and their Creditors" to be known as The Farmers' Creditors Arrangement Act, 1934, and Bill 93, "an Act to amend the Canadian Farm Loan Act," otherwise cited as "The Canadian Farm Loan Act Amendment Act, 1934."

The Farmers' Creditors Arrangement Act, 1934.

Purpose.—The object of this Act is to provide simple and inexpensive machinery and procedure whereby farmers who are unable to meet their liabilities as they become due may propose to their creditors, without actually going into bankruptcy, a composition, extension of time, or scheme of arrangement of their affairs.

Administration.—The administration of the Act is entrusted to the Minister of Finance, the necessary expenses for administration being payable out of any unappropriated moneys in the Consolidated Revenue Fund. The machinery of administration is to consist of one or more official receivers appointed by the Governor in Council in each county or district or for any number of counties or districts of any province to which the Act applies, and a provincial board of review for each province. The provincial boards of review which are to be appointed by the Governor in Council are to consist of a judge of the superior court of the province who shall be chief commissioner, a commissioner to represent the interest of creditors, and one to represent the interests of debtors.

Composition of Liabilities.—The Act provides that any farmer who is unable to meet his liabilities as they become due may make a proposal for a composition, extension of time, or scheme of arrangement either before or after an assignment is made, such proposal to be filed with the official receiver of the district who shall perform the duties of official receiver, custodian and trustee under the Bankruptcy Act.

Following the filing of a proposal with the official receiver, the property of the debtor will be considered as being under the authority of the court and no creditor shall have any remedy against the property or person of the debtor except with the permission of the court, provided that a stay of proceedings shall not be effective for more than sixty days after the filing of the proposal with the official receiver. This period of time may be extended by court order. Any proposal which is approved by the debtor and his creditors becomes binding on all parties.

In any case where the official receiver reports to the Board of Review that a farmer has made a proposal but that no proposal has been approved by the creditors, the Act provides that the Board shall, on written request of a creditor or the debtor, endeavour to formulate a proposal acceptable to all parties concerned. It is required further that such a proposal should be based on the present and prospective ability of the debtor to perform the obligations prescribed and the productive value of the farm. The Board may decline to formulate a proposal in any case where it does not consider that it can do so in fairness and justice to the debtor or the creditors. If any such proposal is approved by the creditors and the debtor, it shall be filed in the court and shall be binding of all persons concerned. Should the debtor or the creditors decline to approve a proposal so formulated, the Board has the power to confirm such proposal either as originally drawn up or as amended by them in which case the proposal will be approved by the court and will be binding on both creditor and debtor.

Interest on Farm Loans.—In connection with interest on farm loans, the Act provides that if, whenever any rate of interest exceeding 7 per cent per annum is stipulated for in any mortgage on farm real estate, the mortgagor tenders or pays to the mortgagee the amount owing on such mortgage and interest to date, together with three months further interest in lieu of notice, no interest shall, after the three months period aforesaid, be chargeable on the mortgage in question at a rate in

excess of 5 per cent per annum. The purpose of this provision is to release farmers from mortgages on which high rates of interest are being paid in order they may take advantage of credit which under the present conditions might be available at lower cost. While the remainder of the Act does not come into force in any province until so proclaimed by the Governor in Council, the above provision regarding rates of interest on farm loans comes into effect immediately.

The Canadian Farm Loan Act Amendment Act, 1934

Purpose.—The purpose of this Act is to further extend the scope of the Canadian Farm Loan Act so that further credit facilities may be placed at the disposal of the farmer in order to enable him to carry on his business.

Powers.—The Act empowers the Board to pay any taxes levied on lands held by the Board as agent of the Crown. Heretofore, such lands were not subject to taxation.

Further additions to the powers of the Board were made providing that additional security on livestock or implements might be obtained where considered necessary to ensure the safety of a loan. The Board was also authorized, in any case where it was considered advisable, to give an extension of time for payment of arrears on loans, to write off amounts owing on account of principal or interest on any loan, and to make advances to borrowers to cover the cost of seed grain, fodder, fertilizer or harvesting expense. The maximum amount of the aggregate loan obtainable under the amended Act was reduced from $10,000 to $7,500.

Funds.—Amendment was also enacted in regard to the financing of the Farm Loan Board providing that the maximum amount of Farm Loan bonds which might be held by the Minister of Finance at any one time should be increased from $15,000,000 to $40,000,000. In order that Farm Loan bonds bearing a low rate of interest might be sold readily to the public, the Act also authorizes the Governor in Council to guarantee the payment of principal and interest on Farm Loan bonds to the amount of $30,000,000.

Further miscellaneous provisions provide for changes to be made in the wording of Farm Loan bonds and for the prepayment of all or part of a loan subject to certain regulations prescribed by the Board.

Supplementary Advances.—This section makes provision for further advances by the Board beyond the limit fixed for first mortgage loans under the Canadian Farm Loan Act. Such an advance may be made to any borrower for a period of not more than six years on the security of a second mortgage on farm lands and of a charge on live stock and other personal property, provided that the aggregate of all loans made to any one borrower does not exceed two-thirds of the appraised value of the land and buildings or the sum of $7,500. The amount advanced on security of the second mortgage and supplementary security may not exceed one-half of that advanced on the security of the first mortgage.

The purposes for which such loans may be used are listed as follows:—

1. To enable debtor to pay existing liabilities.
2. To purchase live stock and equipment necessary for the proper operation of the farm mortgaged.
3. To erect farm buildings or to make any permanent improvements tending to increase the productive value of the land.
4. For any such other purposes relating to the development and operation of the farm as the Board approves.

It is also provided that interest rates for such loans shall not exceed that charged on first mortgage loans by more than one per cent per annum.

Loans to Mortgagees.—In cases where the farmer mortgagor has made an approved composition or arrangement with his creditors under the Farmers' Creditors Arrangement Act, the Board is authorized to make a loan to the mortgagee up to one-quarter of the amount of the mortgage, on condition that such loan be disbursed to

the farmer's account for such purposes in connection with the operation of the farm mortgaged as may be approved by the Board, and the mortgage assigned to the Board as security for the advance. It is further provided that the mortgagee shall not charge the mortgagor a rate of interest on such advances in excess of that payable on the mortgage assigned as security and in no case shall the rate of interest be more than 1 per cent greater than that charged the mortgagee by the Board. The purpose of such a loan is to enable a farmer who has made a composition with his creditors and who would otherwise be unable to finance current farm operations to obtain the necessary working capital. The inducement to the mortgagee to assist the mortgagor is the advantage accruing to him from the continued operation of the mortgaged property by the mortgagor. While the initial period of such a loan is one year, provision is made for extending the time of repayment for a further period not exceeding one year on application of the mortgagee. In this section of the Act "mortgagee" means any loan, trust or insurance company incorporated under Dominion or Provincial laws and may be extended to include such other corporations or persons or classes of corporations or persons as may be designated by the Governor in Council.

MARKETING CONFERENCE AND CO-OPERATIVE INSTITUTE

Under the chairmanship of the newly appointed Minister of Agriculture for Alberta, Honourable F. S. Grisdale, a marketing conference and co-operative institute was held at Olds, Alberta, July 24th to 26th. The first of these conferences was held some years ago and represents an effort on the part of the farmers' organizations, provincial government and university to disseminate the utmost information on marketing questions.

This year special consideration was given to the Natural Products Marketing Act recently passed by the Parliament of Canada. The afternoon and evening of the first day were devoted entirely to this legislation and its possible application to Alberta conditions.

Included among the subjects for discussion on the second and third days were co-operative marketing of wheat, livestock, poultry and dairy products. Dr. H. W. Wood, veteran co-operator of the province, delivered an address on Co-operative Philosophy. The Consumers' co-operative movement was also given a place on the program.

Between two and three hundred were in attendance at the meetings from various parts of Alberta and British Columbia.

The delegates to the conference were quartered in the dormitories of the school of Agriculture and during the several days made full use of the splendid grounds and facilities provided by the institution.

SASKATCHEWAN CO-OPERATIVE CONFERENCE

The Saskatchewan Co-operative Conference was held at the Legislative Buildings, Regina, June 28th and 29th. Mr. C. W. Deaver acted as Chairman of the Conference and Mr. B. N. Arnason of the Co-operation and Markets Branch, Department of Agriculture, was Secretary.

Subjects discussed included: Some Problems of the Co-operative Movement, The Development of Trade with the British Co-operatives, Co-operation Between Consumers' and Producers' Co-operatives, The Development of Consumers' Co-operation, Merchandising of Fuel Oils, A Co-operative Refinery, Co-operative Education, The Natural Products Marketing Act.

Approximately 100 delegates and visitors registered and it was decided that the Conference should convene annually. The following officers were elected: President, C. W. Deaver, Davidson, Saskatchewan; Vice-Presidents, H. L. Fowler, Wilcox, and Mrs. Pearl Johnston, Regina; Secretary, B. N. Arnason, Co-operation and Markets Branch, Department of Agriculture, Regina.

A special session for Managers was devoted to discussion of their problems.

A mimeographed report has been published by the Secretary.

FARMERS' BUSINESS ORGANIZATIONS IN CANADA[1]

Records and statistics properly tabulated and summarized form a basis for investigation and comparative analysis in economic research. Such basic information with respect to the activities of farmers' business organizations for the whole of Canada has not hitherto been available. In certain provinces a record of co-operative activities is obtained each year but in others, with the exception of a return to the Registrar of Companies, no contact has been maintained. For several years the Labour Department of the Dominion Government, with the assistance of some of the provinces, obtained certain information concerning the movement for the purpose of compiling an annual directory. There has, however, been no co-ordinating agency to deal with the accumulation of economic and statistical data necessary for treatment of the subject on a national basis or for the study of experiences and accomplishments in particular fields of activity.

Since one of the purposes for which the Economics Branch was established was to study the farmers' co-operative movement, it was felt that the first step to take should be the acquisition of all the information possible on the activities of such agencies in Canada. To that end arrangements were made for a survey of existing organizations. Information was sought from all farmer-owned and controlled associations, companies, societies, and clubs actively engaged in business regardless of their methods of operation or form of organization. The information thus obtained has now been summarized. It is expected that such a survey will be undertaken annually or at intervals of a few years and that the information obtained will form the basis of a permanent record of co-operative activities.

Summary.—Information obtained by the Economics Branch in the first of these surveys shows that, of the companies at present active, 159 were established within the period from 1880 to 1915. During the next decade and up to the present time organization in business by farmers has made steady growth in numbers, membership and business transacted. The activities of the larger organizations such as wheat pools, live stock and fruit co-operatives have reached a high stage of development, and have received world wide recognition but the combined strength of organization in business of farmers in Canada has never been revealed. There are hundreds of comparatively small organizations which are working quietly and effectively serving local areas which are being discovered and recognized in this survey.

This report covering the business year of 1931 deals with the activities of 795 farmers' business organizations having 2,706 local branches making a total of 3,501 places of business. The shareholders and members financially interested number 379,687. The total investment of shareholders and members amounts to $38,643,598 exclusive of reserves of $7,732,027. Combined assets total $70,226,288 with plant and equipment valued at $45,607,366.

Sales of farm products for the period under review amounted to $134,611,154. The sales value of purchased goods totalled $10,665,503 and other receipts $27,297, which combined means a total business of $145,303,954. It should be kept in mind that this was a period of low prices with the index of farm prices standing at nearly 50 per cent below the 1926 level.

The farm produce marketed co-operatively in Canada as taken from returns received is given as an estimate. Whole milk handled amounted to 1,994,056 hundredweight, butter 34,357,329 pounds, cheese 19,324,907 pounds, apples 2,356,308 boxes and 675,019 barrels, potatoes 809,951 hundredweight. Live stock handlings totalled 3,496,647 hundredweight, poultry 12,341,822 pounds and 16,424,822 dozen eggs, and grain marketed is estimated at 175,580,591 bushels.

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[1] This short article has been adapted from a bulletin entitled "Farmers' Business Organizations in Canada", now in Press. The co-operation of the Department of Labour, Provincial Registrars of Co-operative Associations and a large number of farmers' business concerns is gratefully acknowledged.

ECONOMIC LITERATURE

AYRES, L. P. The Economics of Recovery, MacMillan Co., New York, pp. 185, 1933.

This book reviews the origins and the progress of the depression in the United States and undertakes to make an analysis of the more important measures of legislation that have been enacted to meet the emergency, to consider their economic implications and the probable degree of effective aid that may be expected from them. In the final chapter an attempt is made to identify the fundamental requirements for recovery.

In his "estimate of the situation" Col. Ayres attributes the greater part of the trouble arising out of the depression to two factors. These are—"The great and irregular decline in price levels that paralyzed business" and "the long-drawn-out series of crises in credit."

He classifies all efforts of governments to aid in initiating business recovery from a depression into two groups—efforts to remove barriers blockading business, and attempts to stimulate business, and manipulation of money and credit through inflation. In this connection, he says, "Probably the fundamental principle of wise public policy in dealing with a serious business depression is that the national government should devote its efforts to the removal of those barriers that impede or prevent business recovery." Among these he includes money, the credit system, the railroad industry, taxation and the national budget, and trade relations with foreign nations.

In his discussion of Agricultural Relief, the author is critical of the Agricultural Adjustment Act and deprecates the farmers' need of relief, maintaining that their position has been better than that of industrial workers for some years. In summing up he states, "In the long run the effective remedy is to allow the material rewards of farming to work out their own cure by determining the number of farmers that the country can support . . . . Our experiments in the political planning of Agricultural production and farm prices have so far proved exceedingly costly and almost entirely unsuccessful."

The N.R.A. is denounced by the author as being unsound. Discussing what he terms as the reversal of the sequence of events in a recovery, he says, "In previous periods of business recovery industrial prices and volume of production have moved up ahead of wage increases. This has enabled producers to make profits and so has made it possible for them to secure bank credit with which further to expand output and to increase the volume of employment . . . . This time the theory of the new arrangement is that business should advance the increased purchasing power first, and then trust to resulting greater demands and increased output to make good the advances." He goes on to say that the obstacle in the way of the working out of this theory is that after four years of depression thousands of businesses cannot operate even temporarily at the losses resulting from the increased costs imposed by the new codes and still secure bank credit with which to expand operations.

Discussing inflation, Col. Ayres states, "The prospect of inflation and the programs of the inflationists paralyze initiative in the production of long-term goods because they threaten an indefinite expansion instead of the enduring control of the money and credit of the nation."

With regard to foreign trade, he expresses the opinion that, "Under the circumstances it would seem wise for us to accept as one of the conditions of recovery problem a continuing restriction in the volume and value of our export trade." With this in mind he challenges the wisdom of spending vast sums to open up new agricultural areas, to provide appropriations for agricultural experimentation and education and for loans for farmers.

The last chapter of the book is devoted to requisites for recovery. These are as follows: 1. The expansion of private enterprise rather than expenditure of public funds. 2. The re-establishment of sound money. 3. The re-financing of indebtedness.

CURRENT ECONOMIC PUBLICATIONS

Imperial Economic Committee. Cattle and Beef Survey. A Summary of Production and Trade in British Empire and Foreign Countries I.E.C/S 1, His Majesty's Stationery Office, London, England.

Dominion Bureau of Statistics. Seventh Census of Canada, 1931. Population by Areas. Printing Bureau, Ottawa.

Agricultural Economics Research Institute, Oxford. The Agricultural Register 1933-34. Issued by the Agricultural Economics Research Institute, Oxford, England.

Contributions to Canadian Economics, Vol. VII, 1934. University of Toronto Studies, History and Economics. University of Toronto Press, Toronto.

NOTES

The Cattle Industry Bill (emergency provision) was introduced into the British House of Commons on July 18th. This Bill established a fund to be known as the cattle fund out of which payments may be made on steers, heifers or cow heifers certified to conform to standards prescribed in the Act or on carcases of such animals. In the case of live animals payments shall not exceed 5s. per cwt. or in the case of a carcase shall not exceed 9s. 4d. per cwt., these payments may be made from a date to be proclaimed by the Minister until March 31, 1935, after which they shall cease and it is anticipated that a permanent scheme may come into effect at that time. Imported cattle are to be marked. The payment on an imported animal can only be secured when it is known that it has been in the United Kingdom for at least three months.

Dr. T. W. Grindley, Dominion Bureau of Statistics, Dr. Wm. Allen, University of Saskatchewan, and Dr. J. E. Lattimer, Macdonald College, P.Q., attended the International Conference of Agricultural Economists held at Bad Eilsen, Hanover, Germany, August 26th to September 2nd.

Mr. A. E. Richards, Economics Branch, Department of Agriculture, Ottawa, is at present engaged in a study of certain phases of apple marketing in the Annapolis Valley, Nova Scotia. This study is being conducted in co-operation with the Nova Scotia Department of Agriculture.

G. A. Newman, Assistant Trade Commissioner, London, England, writing in the Commercial Intelligence Journal reports that during the past six months (July 25) there has been more tomato puree, tomato sauce, ketchup and tomato soup imported from Canada into the United Kingdom than from any other country.

The Dairy and Economics Branches of the Federal Department of Agriculture are co-operating with the Dairy Branches of the Provincial Departments of Agriculture in Manitoba, Saskatchewan, and Alberta in a study of creamery management problems in the respective provinces.

G. H. Craig, University of Alberta, has undertaken a study of dairy production and marketing problems in areas surrounding Edmonton and Calgary. Field work in connection with production is now well under way. The Economics Branch, Department of Agriculture, Ottawa, is co-operating in this work.

Marketings of wheat in the three Prairie Provinces during the crop year up to July 27, 1934, were 226,808,811 bushels as compared with 370,611,784 bushels in the same period in 1932-33.

Exports of live cattle from Canada to Great Britain up to August 9, 1934, were 31,475 head as compared with 30,100 head during the same period in 1933.